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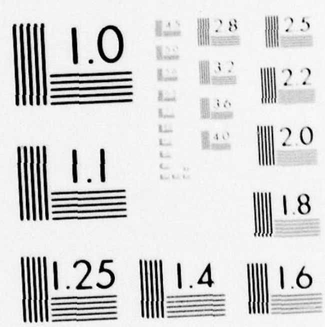

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NWC Technical Memorandum 3558

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TC-2A TECHNICAL EVALUATION

by

L. Law

C. Post

and

W. Haworth

Avionics Division

Systems Development Department

June 1978

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China Lake, California 93555

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As the requirements imposed on the A-7E aircraft increased and future requirements were considered, it was evident that the Tactical Computer, AN/ASN-91(V) (the TC-2), would not be able to handle the increased load. After investigations of four areas of improvement, modifications increasing the speed and capacity resulted in a new computer called the TC-2A. Four preproduction and two production models, manufactured by International Business Machines (IBM) Corporation were evaluated at the Naval Weapons Center (NWC). This report describes the tests facilities and typical tests made in evaluating the units.

The objectives of the technical evaluation of the TC-2A were: (1) to determine under laboratory and controlled flight conditions whether the new computer could be integrated with hardware and software that are used in the A-7E aircraft and receive data from or deliver signals to the tactical computer and, (2) to find its strengths and weaknesses as compared to the TC-2.

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FOREWORD

As the requirements imposed on the A-7E aircraft increased and future requirements were considered, it was evident that the Tactical Computer, AN/ASN-91(V) (the TC-2), would not be able to handle the increased load. After investigations of four areas of improvement, modifications increasing the speed and capacity resulted in a new computer called the TC-2A. Four preproduction and two production models, manufactured by International Business Machines (IBM) Corporation were evaluated at the Naval Weapons Center (NWC). This report describes the testing facilities and typical tests made in evaluating the units in the period from December 1976 through July 1977. The work was done under the authority of the Naval Air Systems Command (AIR 53312A) and funded by AirTask A5335331/0084/6050000001, Work Unit A5331-01.

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29 June 1978

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Tables:

INTRODUCTION

The A-7E aircraft is a highly sophisticated attack airplane capable of precision navigation and weapon delivery. The Navigation and Weapon Delivery System (NWDS) is the unique factor that makes the A-7E an advanced weapon system in the fleet's arsenal. The primary element of the NWDS is the Navigation and Weapons Delivery Computer (NWDC). This computer, designated the AN/ASN-91(V) (TC-2), communicates continuously with the basic avionic sensors of the aircraft. The TC-2 uses computed and stored data to calculate navigation and weapons delivery solutions along with monitoring the reliability of data inputs and outputs from both itself and other avionic sensors throughout the aircraft.

The TC-2, designed and built for the specific purpose of controlling the A-7's navigation and weapon delivery system, has very limited expansion capability. As new stores and mission requirements for the A-7 were increased and as future requirements were considered, it soon became obvious that the TC-2, as it was originally configured, would not be able to handle the increased load. Analysis of the problem revealed that at least three specific areas needed improvement. The three areas suggested for TC-2 improvement are as follows:

1. Speed - The TC-2 Operational Flight Program (OFP) underwent two timing scrubs in the period from 1968 to 1972 and is presently operating at 98% of its capacity. Because of this, it would be impossible to integrate new weapons and their ballistic algorithms or to provide any increase in the complexity of presently used algorithms.

2. Space - The TC-2 OFP also underwent a memory scrub in the same time period and presently operates at about 95% of memory capacity. This also hampers any future growth.

3. Jitter - Synchro information from the Inertial Measurement Set (IMS) is converted from analog to digital. This information is displayed on the Head-Up Display (HUD) by graphic lines generated by the computer. When the magnified HUD view is displayed on the Forward Looking Infrared (FLIR) display, a jitter of noticeable magnitude exists and is considered highly objectionable by the pilot.

In order to alleviate these problems, several major modifications were made to the TC-2. The new computer was called the TC-2A.

In December 1976 and January 1977, the first two of four production models of the TC-2A were sent to Naval Weapons Center (NWC) China Lake, California for technical evaluation. This document is a report of tests and flight history and includes a safety analysis performed during the technical evaluation. The safety analysis is presented in Appendix A as originally published.

It should be noted, that from time to time in this report, three separate and different computers are referred to. They are: 1. the TC-2 computer, which is the standard NWDC used throughout the fleet and the computer to be replaced by the TC-2A, 2. the preproduction model of the TC-2A computer evaluated earlier in the TC-2A program, and 3. the production model TC-2A computer, of which there are two units, IBM Serial Numbers JBB002 and JBB003.

EVALUATION OBJECTIVES

The objectives of the technical evaluation of the TC-2A were: 1. to determine under laboratory and controlled flight conditions whether the new computer could be integrated with hardware and software that are used in the A-7E aircraft and receive data from or deliver signals to the tactical computer and, 2. to find its strengths and weaknesses as compared to the TC-2.

A similar series of tests was run at this facility on a set of four preproduction TC-2As. Some problems were discovered in the areas of wheels drive and synchro conversion error and jitter. Extensive automated testing was developed for the area of synchro conversion. These areas that proved weak or deficient in the preproduction units were given special emphasis in this testing.

TC-2A DESCRIPTION

The TC-2A processor was designed to fill the requirement for a faster, larger memory machine that is compatible with the TC-2 computer and can, at the same time, accommodate tasks beyond the TC-2 capability through direct replacement. The design goals were twofold. First, increase processing speed by 2 to 2.5 times that of the TC-2, increase memory capacity to accommodate 64k 16-bit words, be software-compatible with and execute the current TC-2 OFP without change except for possible programmed delays generated with instruction strings and signal converter coding changes, and access external interfaces through the same connector pins with the same drive and receive circuits at the same bit rates.

The second design goal was to include improvements in the TC-2A processor that could be used to advantage with future development of the A7. Several new instructions have been added, including: shift left and normalize, set bit to memory, absolute value of accumulator, compare byte immediate and skip, shift right double and rotate, shift left double and rotate, zero A and Q, and load base relative. The input/output (I/O) capability of the processor was expanded to include direct memory access input and output.

Logic on the I/O pages has been optimized to provide several interfaces accessing the memory through the use of a Direct Memory Access (DMA) interface. These interfaces include three 50-kHz 20-bit input channels, one 50-kHz and one 0-100-kHz 20-bit output channels, and one half-duplex 100-kHz 17-bit channel.

The TC-2A processor has been updated to fulfill further Navy requirements including: hard base registers, Double Modular Core Memory (DMCM), and memory parity.

The I/O optimization included using more medium scale integration logic, some low-power Schottky TTL circuits, an improved data bussing scheme, and a general speedup of functions.

The signal converter incorporated surge drivers for the wheel outputs and software control of the half-cycle select.

Table 1 compares the characteristics of the TC-2 with those of the TC-2A.

TABLE 1. Comparison of TC-2 and TC-2A Computers.

CHARACTERISTIC	TC-2	TC-2A
Type	General purpose, stored program, parallel, binary	Same
Organization	Fixed point, fractional, two's complement, single address, sequentially executed instructions	Same
Storage	Random access; core: 8192, 32-bit word, destructive readout	Random access; core: 16384, 17-bit words, destructive readout expandable in 16384 modules to 64-k 17-bit words
Storage Cycle Time	2.5 microseconds	800 nanoseconds
Computer Cycle	500 nanoseconds	200 nanoseconds
Addressable Unit	16-bit word	Same
Storage Protection	12,288 16-bit words	All but low 4096 16-bit words of each 16384 word section
Instruction Set	51 instructions tailored for applications such as guidance, navigation, and targeting	63 instructions tailored for applications such as guidance, navigation, targeting, ECM and communications
Word Length	16-bit single precision; 32-bit double precision	Same
Indexing	8 addressing registers in storage (4 base, 4 linkage)	32 maximum addressing registers in hardware and storage (4 base, 4 linkage) in each 16384 word section
Interrupt Facility	5 internally controlled; 4 externally controlled; 2 levels of priority; program mask control	Same plus one more level of priority
Timing Counters Causing Interrupts	50-kHz 16-bit loadable; 50-kHz 10-bit loadable; 50-kHz 16-bit read/reset	50-kHz 16-bit loadable; 50-kHz 16-bit loadable; 50-kHz 16-bit read/reset and GO/NO-GO counter
Execution Times	Add 5 microseconds; multiply 20 microseconds; divide 21 microseconds	Add 1.8 microseconds; multiply 7.8 microseconds; divide 8.2 microseconds
Average Processing Rate	125,000 operations/second	454,000 operations/second (76-18-5-1 formula)
Fail Safe Features	Transient protection and automatic shutdown if cooling system malfunctions; output data signal channels forced to zero state when computer malfunction is detected	Same
Storage Parity	N/A	Parity error on individual word read creates interrupt

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TABLE 1. (Contd.)

CHARACTERISTIC	TC-2	TC-2A
Inputs	Two 50-kHz serial, asynchronous, 20-bit, 1250 words per second plus two designed growth channels	Same-plus
	One 1-MHz serial, program controlled, 16-bit, 2700 words per second	Three 50-kHz serial 20-bit DMA interface
	One 1-MHz serial, program controlled, 20-bit, 2700 words per second	
	One parallel, program controlled 13-bit, 50,000 words per second	
	Two parallel, program controlled, 14-bit, 50,000 words per second designed growth channels	
	Three 10-kHz incremental registers, asynchronous, 10,000 pulses/second/channel	
	Sixty-four logic discretes plus six designed growth discretes	
	Four 28-volt discretes	
Outputs	Two 50-kHz serial, asynchronous, 20-bit, 2500 words per second including one parallel drive channel, plus one designed growth channel	Same-plus
	One 1-MHz serial, program controlled, 16-bit, 27,000 words per second	One 17-bit bidirectional half duplex
	One parallel, program controlled, 13-bit, 50,000 words per second	One 20-bit external clocked channel
	One parallel, program controlled, 14-bit, 50,000 words per second designed growth channel	One 50-kHz 20-bit dual channel
	Three 200-kHz pulse from up-down counter, asynchronous	
	Thirteen logic discretes plus six designed growth discretes	
	Five 28-volt discretes	
	Two 28-volt malfunction discretes	
Dimensions	9.6 x 12.9 X 18.4 inches	10.1 x 12.9 x 18.4 inches
Volume	1.1 cubic feet	1.4 cubic feet
Weight	57 pounds (75 pounds with signal converter or auxiliary storage)	74 pounds
Power Dissipation	225 watts (300 watts with signal converter or auxiliary storage)	441 watts with 32-k memory
Power Input	115V 400-Hz three-phase	Same
Predicted Reliability	Over 2952 hours MTBF	MTBF (averaged over specified lifetime) 1100 hours

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TOOLS AND EQUIPMENT DESCRIPTIONS

Specialized and general test equipment as well as special software routines were used during this evaluation. This section briefly describes the hardware and software tools used and the calibration practices and criteria. The controlled laboratory tests were performed in an aircraft simulation facility maintained at NWC.

HARDWARE EQUIPMENT

Laboratory Test Fixture

The laboratory test procedures were performed in the A-7E Weapons System Integration Laboratory (WepSIL). This facility is an aircraft simulation laboratory capable of performing both static and dynamic flight simulation. It contains a majority of the avionics sensors and equipments of a real A7E aircraft. The laboratory is wired such that all signals from the weapons delivery computer are monitored by a Digital Equipment Corporation's PDP 11/45 digital computer and by special monitoring and testing equipment. All signals going into the navigation and weapons delivery computer may be created by the real hardware that would normally provide the signal, by manually controlled inputs, or by signals simulated by the PDP 11/45. Figure 1 is a photograph of the WepSIL simulation fixture. A block diagram of the WepSIL is presented in Figure 2 showing the major system connections.

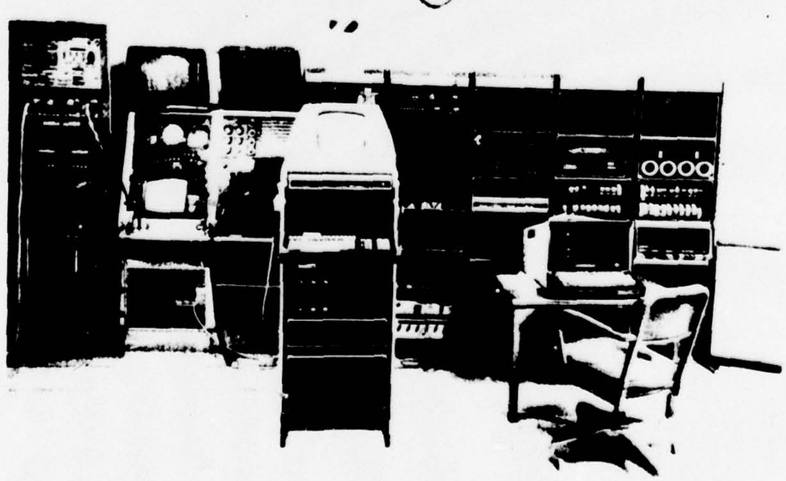

FIGURE 1. WepSIL Simulation Fixture.

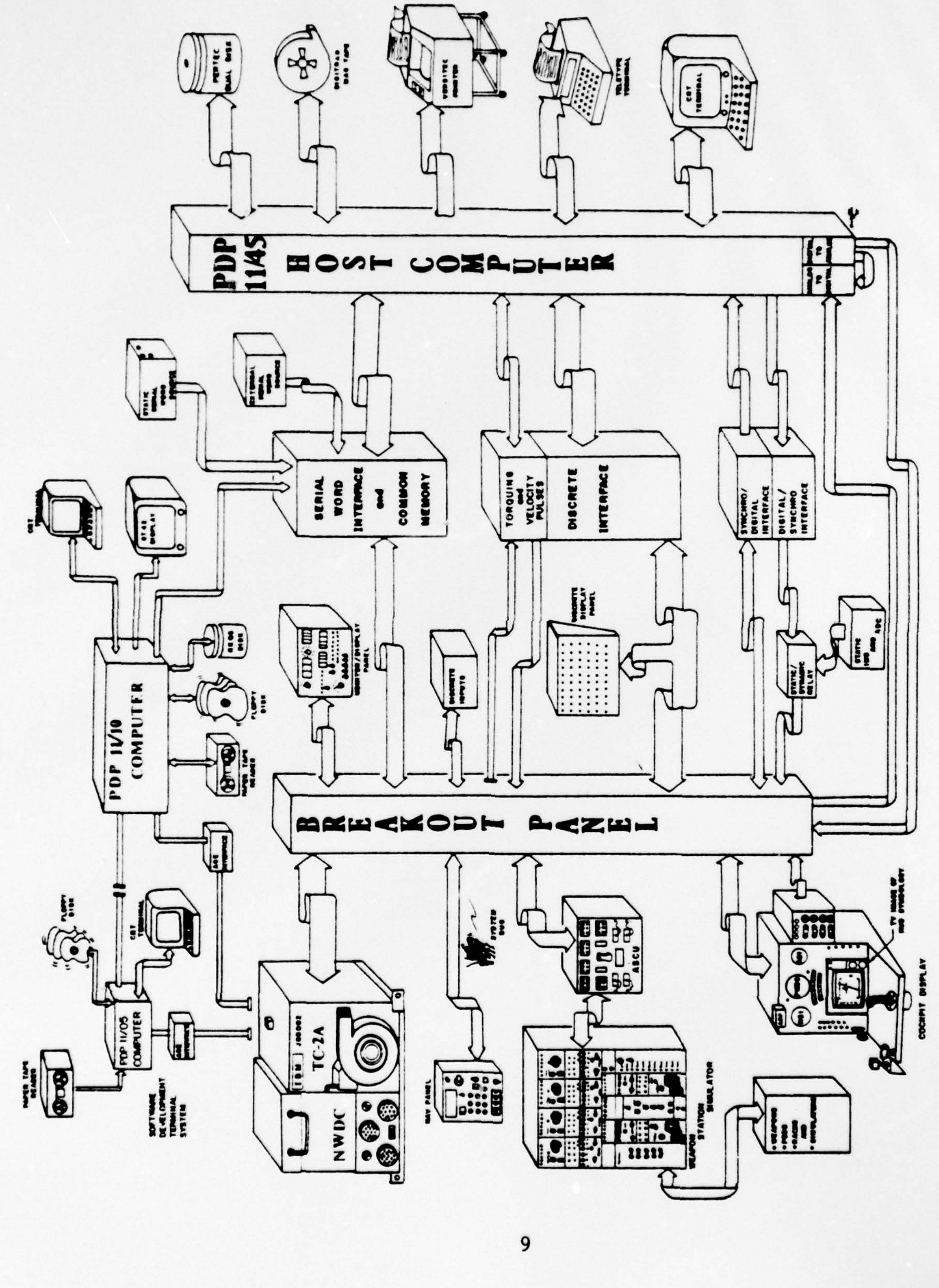

FIGURE 2. WepSIL Block Diagram.

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All signals to and from the NWDC, regardless of how they were created, are wired through a breakout panel where they can be moniored by special test equipment. This feature also allows all lines to be broken for signal insertion and control. Appendix B describes, in detail, the components of the WepSIL that were used in the evaluation of the TC2A computer.

Special Purpose Test Equipment

Several pieces of test equipment were designed, built and added to the WepSIL, specifically to conduct a certain series of tests supporting this technical evaluation. These are a phase shifter, an address monitor and four digital-to-synchro converters. Also, various cables and connectors were fabricated as needed for specific tests.

Phase Shifter. The serial words coming from the PDP 11/45 have a specific phase relationship to each other, but there is no set phase relationship between devices in the real world. The phase shifter is connected between the PDP 11/45 and TC-2A as shown in Figure 3. It allows the setup of any timing relationship desired between channels by delaying channels relative to each other.

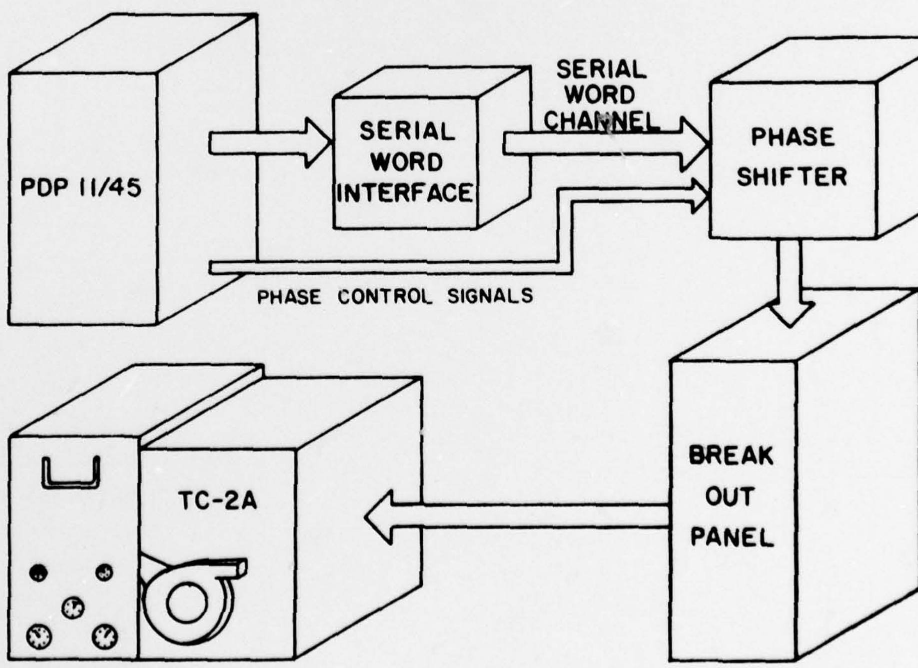

FIGURE 3. Position of Phase Shifter.

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The PDP 11/45 controls the phase shifting for the six channels each of which has a DATA READY, an ADDRESS and a DATA line. The block diagram of a phase shifter for DATA READY is given in Figure 4. Each of the six channels also requires this circuitry for the ADDRESS and for the DATA lines, in addition to the DATA READY lines.

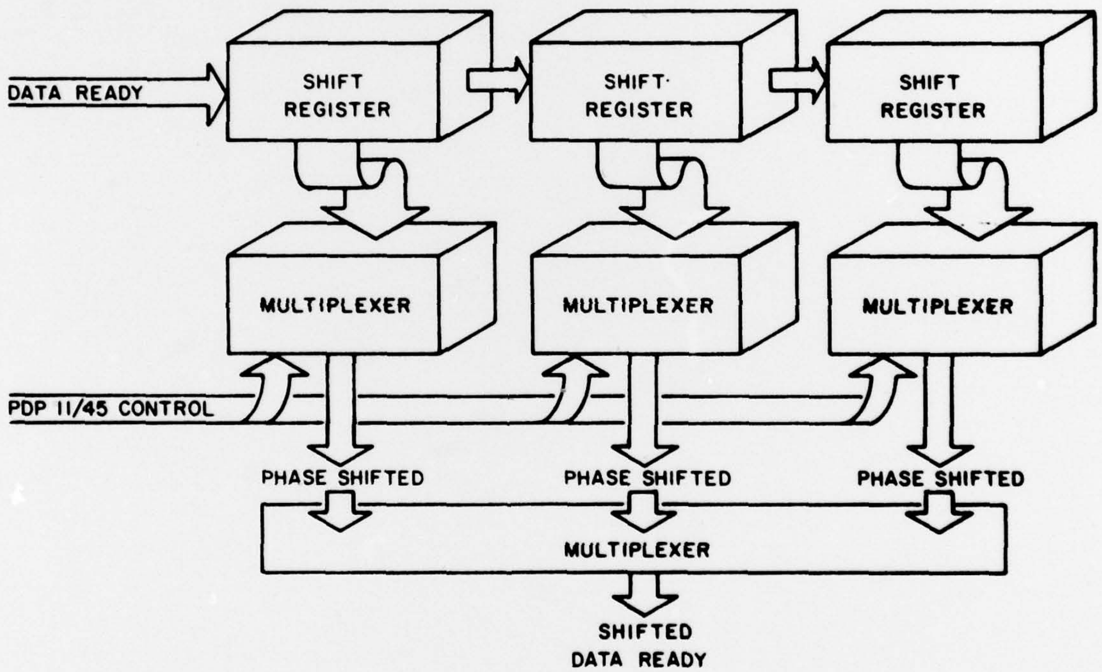

FIGURE 4. Phase Shifter Block Diagram.

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Address Monitor. The address monitor is used to monitor the addresses of serial word channels 5, 6, and 7 (the Direct Memory Access (DMA) channels) going to the TC-2A. The desired address range is set into switches. If any address goes outside the specified range, a Light Emitting Diode (LED) indicator is illuminated. This indicator was included to ensure the PDP 11/45 did not send addresses that were outside the desired range during serial word testing and thus corrupt memory through the DMA channels. Figure 5 is a block diagram of the address monitor.

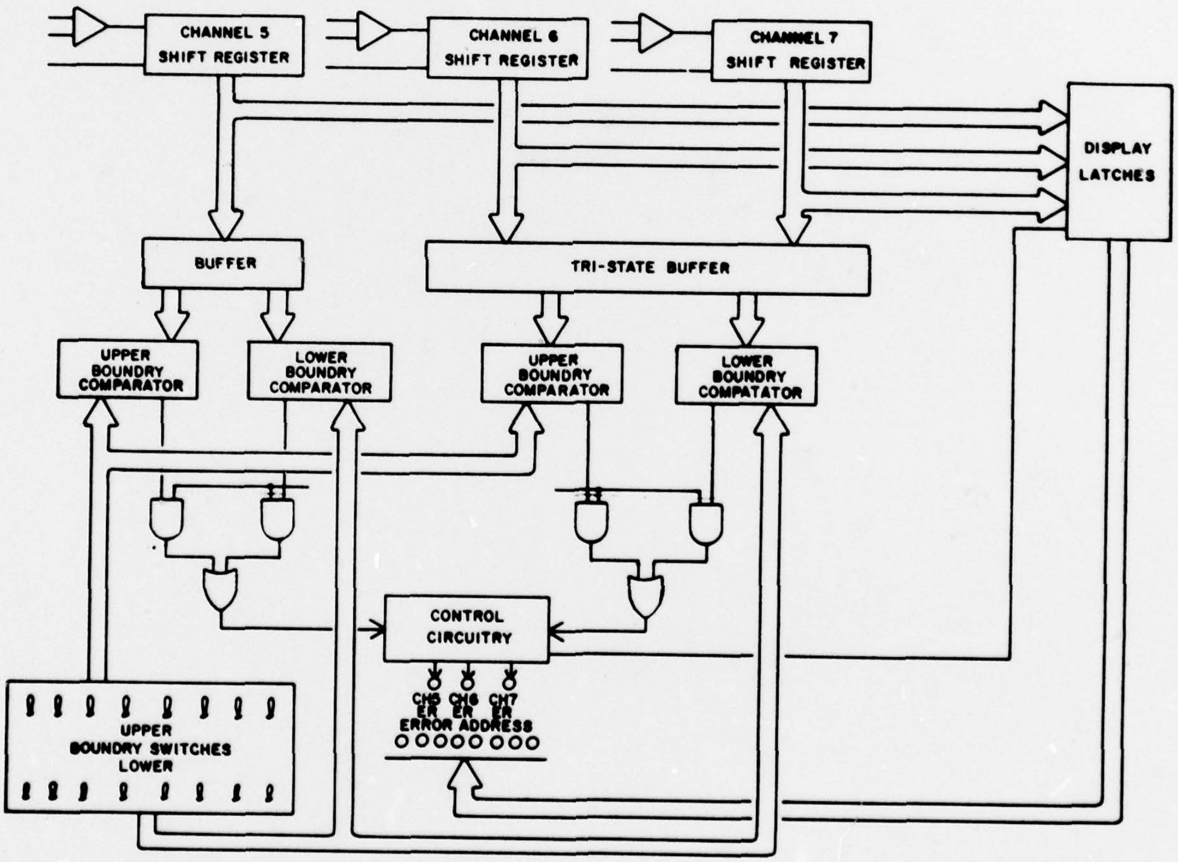

FIGURE 5. Address Monitor Block Diagram.

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Digital-to-Synchro Converters. Two high accuracy (16 bit) and two medium accuracy Digital-to-Syncho (D/S) converters, wired through a relay matrix, were installed between the PDP 11/45 and the TC-2A. The PDP 11/45 provides the digital signals and controls their transmission in such a way that the higher accuracy converters can be switched to provide any two of the four synchro inputs to the TC-2A. Table 2 shows the possible combinations of the high and medium accuracy converters used in tests of magnetic heading, true heading, pitch and roll.

TABLE 2. Synchro Combinations.

Syncho Channels / Combination	Magnetic	True	Pitch	Roll
1	ACC	ACC	MED	MED
2	ACC	MED	ACC	MED
3	MED	ACC	MED	ACC
4	MED	MED	ACC	ACC
5	MED	ACC	ACC	MED
6	ACC	MED	MED	ACC

Note: ACC = high accuracy; MED = medium accuracy

The more accurate synchros are Data Device Corporation's (DDC) model Series A. They have ±1 arc minute accuracy and 16-bit resolution. The 14-bit synchros are North Atlantic's model 785 DS. They are ±4 arc minute accurate and 14-bit resolution.

Standard Test Equipment

Voltage measurements were made on a standard Fluke model 8120A digital multimeter. Rise time and signal quality measurements were made on a Tektronics model 7844 oscilloscope. Both the devices were calibrated at the Naval Weapons Center Calibration Laboratory.

Calibration of Tools, Test Sets, and Laboratory Equipment

Calibration of the standard test equipment was performed on a regular basis. The accuracy of the DDC model Series A digital-to-synchro converters was checked by wiring each one to a calibrated synchro bridge model SB-4C-4R. The D/S converters were then measured at each 5 degrees to insure they were within specification. In addition, during the initial test, the D/S output was monitored by an accurate syncho-to-digital (S/D) device and the digital output from the conversion was compared with the original digital output of the PDP 11/45.

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SOFTWARE TOOLS

Several special purpose software programs were written for the PDP 11/45 computer as well as special hand-loaded patches for the TC-2A computer. The specialized software was necessary to allow certain normal system functions to be examined in real time. These software items are described with the particular test description.

LABORATORY TESTS

This section includes a brief statement of the test conditions and conclusions applied to the hardware areas listed in Table 3 for the two TC-2A computers (Serial Numbers JBB002 and JBB003). Descriptions of the tests and representative samples of data gathered are presented in Appendix C. Data gathered were compared to the TC-2A specification MIL-N-85016 (AS) requirements. Measurements and evaluations were made in accordance with Instrument Society of America Standard ISA-RP55.1 (1971), "Hardware Testing of Digital Process Computers," where possible.

TABLE 3. Hardware Areas Tested.

Analog Signals	Digital Signals
DC OUT	INPUT (CLOCK, DATA, ADDRESS)
Error	Common mode offset error
Settling time	Ability to read all bits
Crosstalk	Ability to start and stop channels
Droop rate	Differential voltage requirements
Drive and regulation	Ability to read channels at all phase relationships
DC IN	SERIAL WORD OUTPUT
Conversion time	Amplitude and phase shift
Conversion error	Readability and word sensitivity
Ratiometric error	Work in burst mode
	Ability to send all bit combinations
SYNCHRO OUT	Drive capabilities
Absolute error	
Crosstalk	
Jitter	
Conversion Time	
SYNCHRO IN	CLOCKS
Conversion error	Frequency
Jitter	Frequency range
Input impedance	
WHEEL DRIVERS	DISCRETE INPUTS
Current limiting	
Drive capabilities	
Error	
ANALOG REFERENCE	CENTRAL PROCESSING UNIT
Error, Jitter and Noise	OFP timing
Drive	New instructions

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TEST CONDITIONS

The primary method used in testing the TC-2A was to install it in the WepSIL fixture, load an OFP and observe and measure the performance. Special software for the PDP 11/45 computer was created to enhance normal system software and to allow for control of certain system software and of certain special test equipments built to perform the tasks.

CONCLUSIONS AND RECOMMENDATIONS

The performance of the TC-2A is superior to that of the TC-2 in every way with the exception of wheels drive at low temperature. Discussions with the A-7E project officer indicate that the set of conditions required to create the marginal wheels drive performance are rare and should not be considered in evaluating the TC-2A. The tests of the analog and synchro conversion functions of the TC-2A were superior to either the TC-2 or the preproduction TC-2A units. The TC-2A outputs (synchro and analog) were remarkably jitter free.

The TC-2A, AN/ASN-91A(V), meets the design specifications and objectives. Therefore approval for service use is recommended.

Appendix A

SYSTEM SAFETY HAZARD ANALYSIS

OF THE

COMPUTER, AN/ASN-91A(V)

PREPARED FOR THE

A-7E PROGRAM OFFICE

BY THE

SYSTEM SAFETY OFFICE

NAVWPNCEN, CODE 36804

Reprinted from the original issue.

1. Summary:

a. The Systems Safety evaluation of the AN/ASN-91A(V) computer revealed no identifiable operational hazards because of computer failure or malfunction. Singular failure of the computer was established as the evaluation criteria.

b. One point of possible hazard during bench test or maintainence was identified. The Time Totalizing Meter terminals are excited by 115 VAC. While the specific computer investigated did have insulation sleeving covering those terminals, removal or degradation of the sleeving is possible. Installation of a warning label is recommended as an added precaution.

c. Interconnect cable pin layout was determined to present no hazards, assuming bent pins causing shorts to adjacent pins within the connector.

2. Discussion:

a. The AN/ASN-91A(V) computer as used in the A-7 aircraft was evaluated for system safety considerations in accordance with guidelines established within Code 36804 in compliance with NAVWPNCEN instruction 5100.12 and the intent of MIL-STD-882.

b. A detailed evaluation of the inputs and outputs of the AN/ASN-91A(V) was conducted to determine if failure or malfunction of the computer could create a hazard. The evaluation was based upon the IWS Subsystems Interface Pictorial Block Diagram (NAVAIR 01-45AAE-2-17), NATOPS Flight Manual (NAVAIR 01-45AAE-1), and Computer NWDS Interface for A7-D/E (IBM Specification 6870605). Attachment (A) lists the functions considered and the best evaluation of the results of a computer malfunction or complete failure. A functional block diagram of the computer was requested but was not available. The conclusions drawn in the evaluation are, therefore, based upon intuitive understanding of the basic navigation and attack problem.

c. The Fault Hazard Analysis (Functional) Attachment (A), did not identify hazards which could be caused by failure or malfunction of the computer. The lack of hazards is due primarily to the utilization of the computer as a central processor with no direct control function in either the navigation or attack modes. Navigation information is received from the various sensors, processed, and the results of the problem solution presented on the displays. The pilot then observes the displays and makes judgments based upon the information. Validity of system performance and equipment operational condition is constantly monitored both by the pilot, using back up equipments, and by comparison or test circuitry designed into the equipment. Corrective action for errors can be taken by the pilot (such as switching to a back up mode of

operation) or in some cases by the computer rejecting information from a failed sensor input and selecting alternate sources or changing mode of operation.

d. Attack modes of operation are similar to the navigation modes with the added functions of the computer to provide some specific computations associated with ballistics, armament release, and gun firing. These specific attack functions are protected from inadvertant occurrence because of the requirement for series selection and action; for example, prior to armament release the Master Function Switch, Armament Release Panel, Armament Select Switch, and Pilots Stick Grip must be properly activated before the computer can provide release pulses which will effect a release of armament. These essential series controls make the erroneous release of armament, through computer malfunction or failure, highly improbable.

e. A Maintenance Hazard Analysis was conducted by review of maintenance handbooks for the AN/ASN-91 computer. Handbooks for the AN/ASN-91A were not available. The handbooks reviewed contained adequate safety warnings and notices to prevent injury to personnel or damage to equipment. Warnings were inserted regarding removal of power prior to servicing, where warranted. Cautions were inserted to warn of the weight of the computer when handling was required. Cautions were also inserted to inspect pins of cables and connectors prior to mating to preclude equipment damage.

f. An additional portion of the Maintenance Hazard Analysis consisted of viewing one unit of the presently configured AN/ASN-91A computer. Warning signs were in place on the primary power circuitry and the 115 VAC lead to the blower motor was adequately protected by a "boot" type insulator over the connection as well as a metal protective cover.

g. One area of possible hazard was the input power to the Time Totalizing Meter. The connections on this meter, on this computer, were covered with sleeving slipped over the wire and soldered connection. The connections were accessible by inserting the hand into the computer with the computer side covers removed. Side covers are normally removed during bench testing and troubleshooting. While this hazard cannot be justifiably categorized as Category II, it is deemed advisable to recommend installation of a warning placard to identify the existance of 115 VAC at that point.

h. It must be reemphasized that the Maintenance Hazard Analysis was conducted on handbooks for the AN/ASN-91(V) not the AN/ASN-91A(V) and the equipment observed was presented as one of two pilot production models in existance. Care should be exercised in future handbooks and future equipments to incorporate equal or greater safety features.

i. Evaluation of the connector pin layout for the computer to aircraft interface was made to identify possible hazards caused by

misconnection or bent pins. The selection of pin arrangement appears to have been carefully thought out and no hazardous conditions were identified. Seperate connectors are used for data channels and power. The power connector, J5, is spaced such that maximum distance seperates the input power from secondary power levels. Shorting of data channel pins would result in data errors, either input or output. The result would be similar to that expected for computer failure.

3. Conclusions:

The AN/ASN-91A(V), as submitted for analysis, meets the requirements relating to safety in design; therefore, Approval for Service Use is recommended.

PROGRAM A7-E
SYSTEM NAV/WPN DELIVERY
SUBSYSTEM AN/ASN-91A

NWC 5100/21 (10-76)

SYSTEM SAFETY

FAULT HAZARD ANALYSIS (FUNCTIONAL)

DATES 19 MAY 1977
PAGE 1 OF 6 PAGES
PREPARED BY P. MELTON

REF.*	FUNCTION	FAILURE MECHANISM	CAUSE	EFFECT (Immediate)	EFFECT (System)	HAZARD DESCRIPTION	DETECTION	KNOWN CONTROLS	HASK
IBM SPECIF. NO. 6870605	INPUTS FROM DOPPLER RADAR SET:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	NO DOPPLER STABILIZATION TO IMS	DEGRADATION OF AUTOMATIC NAV/ATTACK ACCURACY	NONE	PILOT DETECTION BY VISUAL OBSERVATION OF DISPLAYS AND STATUS PANEL	PILOT CONTROLS MODE OF OPERATION CAN SWITCH TO BACK UP MODELS	
	DOPPLER DATA DOPPLER ADDRESS DOPPLER READY	COMPUTER RESPONDS ERRONEOUSLY	COMPUTER MALFUNCTION	ERRONEOUS DOPPLER INFORMATION TO IMS	SAME	NONE	SAME	SAME	
	OUTPUTS TO DOPPLER RADAR SET: SERIAL CHANNEL CLOCK	NO OUTPUT FROM DOPPLER	NO SERIAL CHANNEL CLOCK	NO DOPPLER OUTPUT TO COMPUTER	SAME	NONE	SAME		
	INPUTS FROM FORWARD LOOKING RADAR:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	NO RADAR DATA FROM FLR	DEGRADATION OF AUTOMATIC NAV/ATTACK ACCURACY	NONE	PILOT OBSERVATION OF DISPLAYS	PILOT CONTROLS MODE OF OPERATION CAN SWITCH TO BACK UP MODES	
	RADAR DATA RADAR ADDRESS RADAR READY	COMPUTER RESPONDS ERRONEOUSLY	COMPUTER MALFUNCTION	AUTOMATIC PRESENTATION NOT COMPLETE OR IN GROSS ERROR	SAME	NONE	SAME	SAME	
	OUTPUT TO FORWARD LOOKING RADAR:	NO OUTPUT	COMPUTER FAILURE	AUTOMATIC RADAR PRESENTATION NOT COMPLETE	DEGRADATION OF AUTOMATIC NAV/ATTACK ACCURACY	NONE	PILOT OBSERVATION	SAME	
	SERIAL CHANNEL CLOCK RADAR DATA RADAR ADDRESS RADAR READY EL. STEERING AZ. STEERING GROUND TRACK FLT. PATH ANGLE COMPUTER RELIAB. CURSOR ENABLE ANT SLAVE COMM. COMMAND TEST	PROVIDES ERRONEOUS OUTPUTS	COMPUTER MALFUNCTION	GROSS ERRORS IN PRESENTATION	UPDATE OF POSITION NOT POSSIBLE WITH RADAR	NONE	SAME	SAME	
	OUTPUTS TO HORIZ. SITUATION INDICATOR:	NO COMPUTER OUTPUTS	COMPUTER FAILURE	NO HSI DISPLAY	DEGRADED AUTO NAV/ATTACK DISPLAY ACCURACY	NONE	PILOT OBSERVATION	PILOT CONTROL CAN USE BACK UP MODES FOR CONTROL	
	BEARING TO DEST. REL. GND. TR. RNG. TO DEST. BOMB TONE 1000 N.M. DIGIT	ERRONEOUS COMPUTER OUTPUTS	SAME	GROSS ERRORS IN HSI DISPLAY	SAME	NONE	SAME	SAME	
	OUTPUTS TO ATTITUDE DIRECTION INDICATOR:	NO COMPUTER OUTPUTS	COMPUTER FAILURE	NO ADI DISPLAY FOR STEERING ERROR OR COMPUTER RELIAB.		NONE	PILOT OBSERVATION	PILOT USES BACK UP MEANS FOR CONTROL	
	STEERING ERROR COMPUTER RELIAB.	ERRONEOUS COMPUTER OUTPUTS	SAME	GROSS STEERING ERROR		NONE	SAME	SAME	

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PROGRAM A7-E
SYSTEM NAV/WPN DELIVERY
SUBSYSTEM AN/ASN-91A

SYSTEM SAFETY
FAULT HAZARD ANALYSIS (FUNCTIONAL)

NWC 5100/21 (10-76)

DATES 19 MAY 1977
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REF *	FUNCTION	FAILURE MECHANISM	CAUSE	EFFECT (Immediate)	EFFECT (System)	HAZARD DESCRIPTION	DETECTION	KNOWN CONTROLS	HASK
IBM SPECIF. NO. 6870605	INPUTS FROM ARMAMENT RELEASE PANEL: WEAPON QUANTITY (80, 40, 20, 10, 8, 4, 2, 1) WEAPON SPACING (800, 400, 200, 100, 80, 40, 20, 10)	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	WEAPON QUANTITY, SPACING, AND PAIRS NOT SELECTED	WEAPON RELEASE NOT POSSIBLE IN AUTO MODE	NONE	PILOT OBSERVATION	IN AUTO MODE ARMAMENT CANNOT BE RELEASED WITHOUT INPUTS FROM ARMAMENT RELEASE PANEL. PILOT CAN SWITCH TO BACK UP MODE.	
	INPUTS FROM HEADS UP DISPLAY: HUD RELIABLE	COMPUTER DOES NOT RESPOND TO HUD INPUT	COMPUTER FAILURE	NO HUD INFO FROM COMPUTER DISPLAYED	DEGRADED AUTO NAV/ATTACK ACCURACY	NONE	PILOT OBSERVATION	PILOT USES BACK UP DISPLAYS	
	OUTPUTS TO HEADS UP DISPLAY (HUD): HUD DATA HUD ADDRESS HUD READY	NO DATA OUT FROM COMPUTER TO HUD	COMPUTER FAILURE	NO HUD INFO FROM COMPUTER DISPLAYED	DEGRADED AUTO NAV/ATTACK ACCURACY	NONE	PILOT OBSERVATION	PILOT USES BACK UP DISPLAYS	
	SERIAL CHANNEL CLOCK SER OUT 3 DATA SER OUT 3 SER OUTPUT 3 DATA READY SER OUTPUT 3 CLOCK	ERRONEOUS OUTPUT FROM COMPUTER TO HUD	COMPUTER FAILURE	GROSS INACCURACY IN HUD DISPLAY	SAME	NONE	SAME	SAME	
	INPUTS FROM ARMAMENT STATION CONTROL UNIT (ASCU):	COMPUTER DOES NOT RESPOND TO ASCU INPUT	COMPUTER FAILURE	NO ARMAMENT CONTROL BY COMPUTER	ATTACK MISSION CANNOT BE COMPLETED IN AUTO MODE	NONE	SAME	PILOT CAN USE MANUAL MODE	
	WEAPON TYPE (80, 40, 20, 10, 8, 4, 2, 1) STATION READY (1, 2, 3, 6, 7, 8) GUNS SELECTED MULTIPLE LOADING RELEASE ENABLE TR. DISP. BOMB SEL	COMPUTER READS INPUTS ERRONEOUSLY	COMPUTER MALFUNCTION	WRONG WEAPON TYPE OR STATION READY INFO.	NO RELEASE OF WEAPON - COMPUTER AND ASCU MUST AGREE FOR RELEASE	NONE	SAME	SAME	
	OUTPUTS TO ASCU: BOMB RELEASE FIRE READY	COMPUTER PROVIDES RELEASE OR FIRE OUTPUT PREMATURELY	COMPUTER MALFUNCTION	NONE	PREMATURE RELEASE OF ARMAMENT	NONE	PILOT OR CREW OBSERVATION	ARM RELEASE REQUIRES SELECTION ON (1) ARMAMENT RELEASE PANEL, (2) ASCU, AND (3) DEPRESSION OF ARM RELEASE ON PILOT STICK GRIP	
	INPUTS FROM MASTER FUNCTION SWITCH:	COMPUTER DOES NOT RESPOND TO SELECTED INPUT	COMPUTER FAILURE	NONE	AUTO NAV/ATTACK FUNCTION INOP.	NONE	PILOT OBSERVATION	PILOT CAN USE BACK UP MANUAL MODE	
	NORMAL MODE OFFSET MODE RADAR BOMB NAV/BOMB TERRAIN FOLLOWING	COMPUTER RESPONDS ERRONEOUSLY TO SELECTED INPUT, I.E., WRONG RESPONSE TO INPUT - INTERPRETS NORMAL MODE AS RADAR BOMB ETC.	COMPUTER MALFUNCTION	WRONG MODE SELECTED	DEGRADED AUTO NAV/ATTACK PERFORMANCE	NONE	PILOT OBSERVATION	SAME	
	INPUTS FROM PILOT STICK GRIP:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	PILOT CANNOT CORRECT OR ALTER DISPLAYS OR COMPUTER SOLUTIONS	AUTO NAV/ATTACK FUNCTION INOP.	NONE	PILOT OBSERVATION	PILOT CAN USE BACK UP MANUAL MODE	
	AZIMUTH RATE ELEVATION RATE TARGET DESIGNATE NOT BFL PULSE 1 BFL PULSE 2	COMPUTER RESPONDS ERRONEOUSLY TO INPUTS	COMPUTER MALFUNCTION	ERRONEOUS AUTO DISPLAYS AND COMPUTER SOLUTIONS	DEGRADED AUTO NAV/ATTACK SOLUTIONS	NONE	PILOT OBSERVATION	SAME	

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PROGRAM A7-E
SYSTEM NAV/WPN DELIVERY
SUBSYSTEM AN/ASN-91A

FIND-NWC 5100/21 (10-76)

SYSTEM SAFETY

FAULT HAZARD ANALYSIS (FUNCTIONAL)

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REF.*	FUNCTION	FAILURE MECHANISM	CAUSE	EFFECT (Immediate)	EFFECT (System)	HAZARD DESCRIPTION	DETECTION	KNOWN CONTROLS	HASR
IBM SPECIF. NO. 6870505	OUTPUTS TO PILOT STICK GRIP: POT EXCITATION	NO EXCITATION	COMPUTER FAILURE	NO CONTROL OF COMPUTER FROM PILOT STICK GRIP	AUTO NAV/ATTACK FUNCTION INOP.	NONE	PILOT OBSERVATION	PILOT CAN USE BACK UP MANUAL MODE	
	OUTPUTS TO ADVISORY CAUTION PANEL: COMP. SYS. FAIL; IMU NOT ALIGNED	NO OUTPUTS TO ADVISORY PANEL	COMPUTER FAILURE	NONE	NONE, UNLESS COMPUTER FAILS OR IMU IS NOT ALIGNED	NONE	PILOT OBSERVATION	SAME	
	INPUTS FROM (ADC) AIR DATA COMPUTER	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	COMPUTER OUTPUTS NOT AVAILABLE	DEGRADED OR NON-EXISTENT AUTO NAV/BOMB SOLUTION	NONE	COMPUTER	COMPUTER SWITCHES TO WIND MEMORY MODE	
	TRUE AS (CH 2); TRUE AS (CH 3); BARO ALTITUDE; MACH #1; ADC FAIL	COMPUTER RESPONDS ERRONEOUSLY TO INPUTS	COMPUTER MALFUNCTION	COMPUTER OUTPUTS IN ERROR	DEGRADED AUTO NAV/ATTACK PERFORMANCE	NONE	PILOT OBSERVATION OF NAV ACCURACY AND COMPARISON TO OTHER DISPLAYS	PILOT CAN SET IN WIND VELOCITIES	
	OUTPUTS TO ADC: POT EXCITATION; COMMAND TEST	NO OUTPUT TO ADC	COMPUTER FAILURE	NO INPUT FROM ADC TO COMPUTER-ERRONEOUS SOLUTIONS	DEGRADED NAV/ATTACK SOLUTION	NONE	SAME	SAME	
	INPUTS FROM NAV. WPN. DEL. PANEL (NAV/WD):	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	COMPUTER OUTPUTS NOT AVAILABLE	NO SOLUTION OF NAV/ATTACK PROBLEM	NONE	PILOT OBSERVATION	PILOT CAN SELECT TO BACK UP MODES	
	DATA IN; SELF TEST; NAV/WD PANEL INTERRUPT; INPUT POWER (DC)	COMPUTER RESPONDS TO INPUTS ERRONEOUSLY	COMPUTER MALFUNCTION	COMPUTER OUTPUTS IN ERROR	DEGRADED OR NON-EXISTENT NAV/ATTACK SOLUTION	NONE	SAME	SAME	
	OUTPUTS TO NAV/WD PANEL:	NO OUTPUT TO NAV/WD PANEL	COMPUTER FAILURE	COMPUTER OUTPUTS NOT AVAILABLE	NO SOLUTION OF NAV/ATTACK PROBLEM	NONE	SAME	SAME	
	DATA OUT; ADDRESS (1, 2, 3, 4); READ; WRITE; SHIFT CLOCK; CLOCK (TIMING); PWR. ON RESET DELAYED; POWER SUPPLY VOLTAGES (+5VDC, 23 EA.); POWER SUPPLY VOLTAGE (-5 VDC, 1 EA.); POWER SUPPLY VOLTAGE (+12 VDC, 1 EA.); POWER SUPPLY VOLTAGE (10 VAC, 3 EA. HI & LO); BASIC RATE (1, 2, 4, 8); SPECIFIC RATE (1, 2, 4, 8); CDA 10F (1, 2, 4, 8); CDA 1F (1, 2, 4, 8); CDB 10F (1, 2, 4, 8); CDB 1F (1, 2, 4, 8); START SEARCH (M, A, B); LORAN C; RELAY CONTROL; OSC HEATER	ERRONEOUS OUTPUT TO NAV/WD PANEL	COMPUTER MALFUNCTION	COMPUTER OUTPUTS IN ERROR	ERRONEOUS SOLUTION TO NAV/ATTACK PROBLEM	NONE	SAME	SAME	

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PROGRAM A7-E
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SYSTEM SAFETY

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REF. *	FUNCTION	FAILURE MECHANISM	CAUSE	EFFECT (Immediate)	EFFECT (System)	HAZARD DESCRIPTION	DETECTION	KNOWN CONTROLS	HASR
IBM SPECIF. NO. 6870605	INPUTS FROM TACAN:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	NO TACAN SOLUTION	DEGRADED NAV SOLUTION	NONE	PILOT OBSERVATION	PILOT CAN SELECT BACK UP MODES	
	DATA IN	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	ERRONEOUS TACAN SOLUTION	DEGRADED NAV SOLUTION	NONE	SAME	SAME	
	OUTPUTS TO TACAN:	NO OUTPUT	COMPUTER FAILURE	NO TACAN SOLUTION	DEGRADED NAV SOLUTION	NONE	SAME	SAME	
	ADDRESS OUT READ COMMAND CLOCK (SHIFT)	ERRONEOUS OUTPUT	COMPUTER MALFUNCTION	ERRONEOUS TACAN SOLUTION	DEGRADED NAV SOLUTION	NONE	SAME	SAME	
	INPUTS FROM ANGLE OF ATTACK SENSOR:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	NO ANGLE OF ATTACK DATA	DEGRADED NAV/ATTACK SOLUTION	NONE	SAME	SAME	
	ANGLE OF ATTACK (ANALOG)	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	ERRONEOUS ANGLE OF ATTACK DATA					
	INPUTS FROM RADAR ALTIMETER:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	NO RADAR ALT. DATA	DEGRADED NAV/ATTACK SOLUTION	NONE	PILOT OBSERVATION	SAME	
	RADAR ALTITUDE	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	ERRONEOUS RADAR ALT. DATA					
	INPUTS FROM DIGITAL SINS:	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	IMS CANNOT BE ALIGNED	DEGRADED IMS ACCURACY EFFECTS NAV/ATTACK ACCURACY	NONE	PILOT OR GROUND CREW OBSERVATION	SAME	
	SINS DATA SINS ADDRESS SINS READY	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	IMS ALIGNED IN ERROR		NONE	SAME	SAME	
	OUTPUTS TO DIGITAL SINS:	NO OUTPUT	COMPUTER FAILURE	IMS CANNOT BE ALIGNED	DEGRADED IMS ACCURACY EFFECTS NAV/ATTACK ACCURACY	NONE	SAME	SAME	
	SERIAL CHANNEL CLOCK	ERRONEOUS OUTPUT	COMPUTER MALFUNCTION	IMS ALIGNED IN ERROR					
	INPUTS FROM LASER:	COMPUTER DOES NOT RESPOND TO INPUT	COMPUTER FAILURE						
	LASER DATA LASER ADDRESS LASER READY	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION						
	OUTPUTS TO LASER:	NO OUTPUT	COMPUTER FAILURE						
	SER. CHANNEL CLOCK	ERRONEOUS OUTPUT	COMPUTER MALFUNCTION						

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PROGRAM 47-E
SYSTEM NAV/WPN DELIVERY
SUBSYSTEM AN/ASN-91A

NWC 5100/21 (10 76)

SYSTEM SAFETY

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REF *	FUNCTION	FAILURE MECHANISM	CAUSE	EFFECT (Immediate)	EFFECT (System)	HAZARD DESCRIPTION	DETECTION	KNOWN CONTROLS	HASR
IBM SPECIF. NO. 6870605	INPUTS FROM INERTIAL MEAS. SET (IMS): PITCH ROLL TRUE HEADING MAG HEADING INC VEL (EAST, NORTH) INU. VEL. (EAST, NORTH) VERTICAL VEL. (POS., NEG.) IMS FAIL IMS READY GROUND ALIGN. NORMAL MODE INERTIAL MODE PLATFORM GRID MODE MAG. SLAVE AUTO CALIBRATE	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	NO COMPUTER SOLUTION FOR NAV/ATTACK	DEGRADED NAV/ATTACK ACCURACY	NONE	PILOT OBSERVATION	PILOT CAN SELECT BACK UP MODE	
		COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	ERRONEOUS SOLUTION FOR NAV/ATTACK	SAME	NONE	SAME	SAME	
	OUTPUTS TO IMS: GYRO TORQUING (WX, WY, WZ) SAMPLE CLOCK SCALE FACTOR CHG. AZ SLEW AZ SLEW SENSE LAT 70 DEG. COMPUTER FAILED COMP. CTRL. MODE AUTO CALIB. X SLEW X SLEW SENSE Y SLEW Y SLEW SENSE	NO OUTPUT	COMPUTER FAILURE	NO COMPUTER STABILIZATION OR CONTROL OF IMS	SAME	NONE	SAME	SAME	
		ERRONEOUS OUTPUT	COMPUTER MALFUNCTION	ERRONEOUS STABILIZATION OR CONTROL OF IMS	SAME	NONE	SAME	SAME	
	INPUT FROM ARMAMENT SELECT PANEL:	COMPUTER DOES NOT RESPOND	COMPUTER FAILURE	ARMAMENT RELEASE NOT POSSIBLE	DEGRADATION OF AUTO BOMB CAPABILITY	NONE			
	014-BOMB HIGH (DRAG)	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	ARMAMENT RELEASE IN ERROR					
	INPUTS FROM AIRCRAFT (A/C):	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE	COMPUTER CANNOT BE OPERATED NOR PROGRAMMED	NAV/ATTACK SYSTEM WOULD NOT CHECK OUT BEFORE FLIGHT. SYSTEM WOULD INDICATE FAIL IN FLIGHT	NONE	BIT AND PILOT DISPLAYS PERMIT DETECTION OF GROSS FAILURES		
	LAND/CARRIER SW LAND GEAR COMPRESSED SYNCHRO. EX. REF. INPUT POWER (115 VAC 400 HZ) SINS SYNCH. REF. IMBEDDED LIGHT (5 VAC) INPUT POWER (+28 VDC) DAY/NIGHT DISCR.	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	COMPUTER WILL NOT PASS THE MAINTENANCE TEST PROGRAM BEFORE FLIGHT WOULD NOT PERFORM PROPERLY IN FLIGHT	DEGRADED PERFORMANCE IN AUTOMATIC NAV/ATTACK MODE	NONE	SAME		
	OUTPUTS TO A/C:	NO OUTPUT	COMPUTER FAILURE						
	PWR TO CONTACTOR (+28 VDC) LOW ALT.	ERRONEOUS OUTPUT	COMPUTER MALFUNCTION						

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PROGRAM A7-E

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SYSTEM SAFETY

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REF. *	FUNCTION	FAILURE MECHANISM	CAUSE	EFFECT (Immediate)	EFFECT (System)	HAZARD DESCRIPTION	DETECTION	KNOWN CONTROLS	HASR
IBM SPECIF. NO. 6870605	INPUTS FROM PROJECTED MAP DISPLAY UNIT (PMDU)	COMPUTER DOES NOT RESPOND	COMPUTER FAILURE	ERRONEOUS PMDU DISPLAY	DEGRADED MAP DISPLAY	NONE	PILOT OBSERVATION	PILOT CAN SELECT BACK UP MODE	
	SCALE SELECT HOLD COMMAND DECENTER SELECT NORTH UP SELECT	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION	SAME	SAME	NONE	SAME	SAME	
	OUTPUTS TO PMDU:	NO OUTPUT	COMPUTER FAILURE	SAME	SAME	NONE	SAME	SAME	
	RNG. TO DEST. (UNITS, TENS, HUND.) PMDS DATA PMDS ADDRESS PMDS READY PMDS CLOCK	ERRONEOUS OUTPUT	COMPUTER MALFUNCTION	SAME	SAME	NONE	SAME	SAME	
	INPUTS FROM FWD. LOOKING INFRARED (FLIR):	COMPUTER DOES NOT RESPOND TO INPUTS	COMPUTER FAILURE						
	FLIR ON SERVO FAIL DIG. CH. FAIL DI #5 BIT 13	COMPUTER RESPONDS IN ERROR	COMPUTER MALFUNCTION						
	OUTPUTS TO FLIR:	NO OUTPUT	COMPUTER FAILURE						
	SER OUT 3 DATA SER OUT 3 ADDRESS SER OUT 3 DATA READY SER OUT 3 CLOCK								

NOTE: ANALYSIS OF LASER AND FLIR INTERFACE NOT PERFORMED BECAUSE DETAILS OF FUNCTIONAL INPUTS AND OUTPUTS NOT AVAILABLE AT TIME OF REVIEW.

* DOCUMENT

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Appendix B

WEPSIL TEST EQUIPMENT

The major components of the WepSIL facility that were used in the evaluation of the TC-2A are described, including functional block diagrams of two special hardware devices fabricated by the A-7 Program Office to aid in the TC-2A technical evaluation.

MONITOR PANEL

Figure B-1 depicts the WepSIL monitor panel which is a permanently mounted piece of test equipment that allows the visual monitoring of all signals going to and from the NWDC. The operator can select any analog signal and have it displayed on the digital panel meter. Any of six sets of two or three synchro signals can be selected and displayed on the Data Device Corporation's model SR 300 digital angle position indicators. Any of the 20-bit serial words, other than those added to the TC-2A, may be selected and any serial word address within that channel may then be selected and displayed continuously in bit-by-bit fashion on discrete LED indicators. A similar display arrangement is used for the 1-MHz 20-bit words. The torquing and velocity pulses are routed to connectors where they can be monitored by standard oscilliscopes and counters.

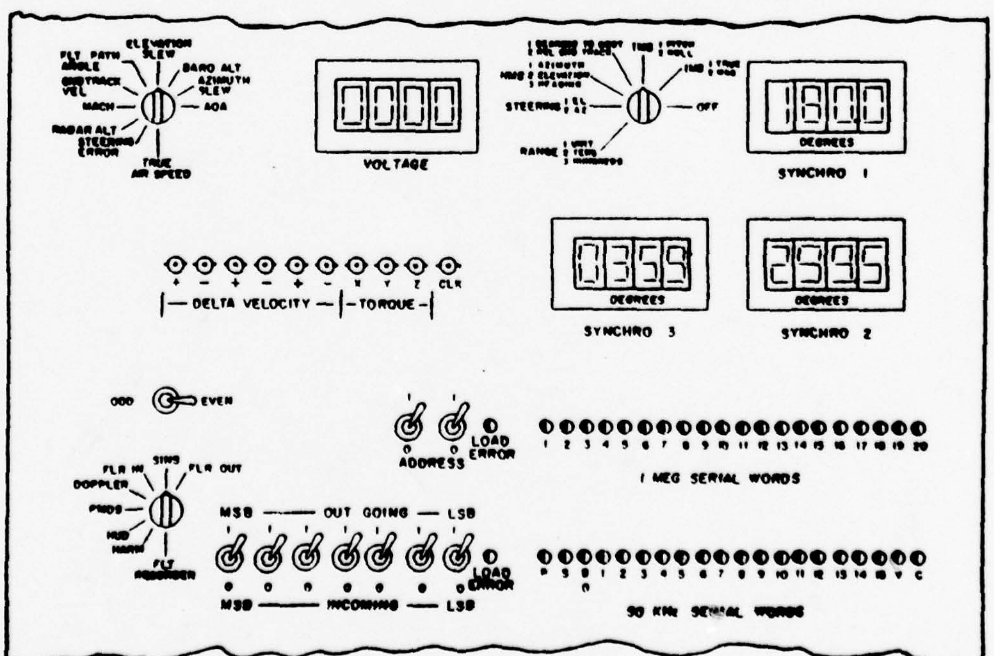

FIGURE B-1. WepSIL Monitor Panel.

GENERAL PURPOSE SERIAL WORD TRANSMITTER

The general purpose serial word transmitter (Figure B-2) is a separate box which is not permanently mounted in the WepSIL. It is used to provide up to six serial words with valid data and up to 122 serial words with not valid data. The addresses may be anywhere between 00_{16} and $7F_{16}$. Both data values and address values may be set by thumbwheel switches on the front panel. This device is used to test serial word common mode noise rejection and line-to-line signal degradation effect.

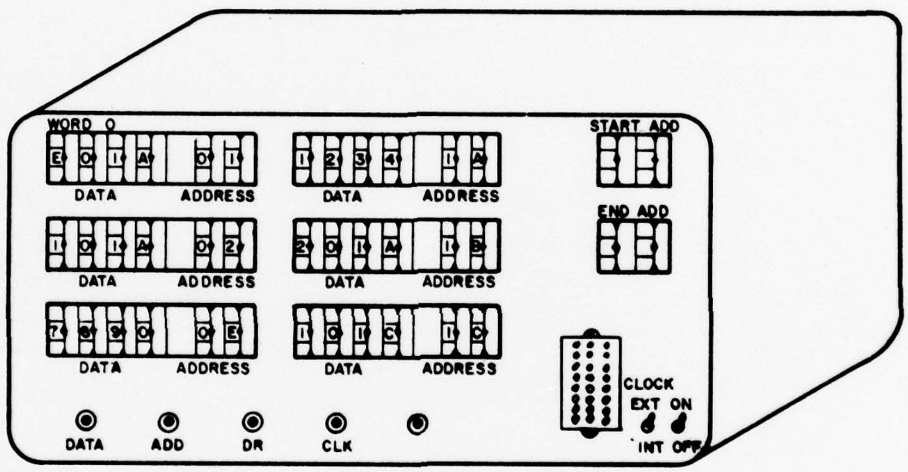

FIGURE B-2. General Purpose Serial Word Transmitter.

SERIAL WORD INTERFACE AND COMMON MEMORY

This section of the WepSIL is permanently mounted in the fixture. It has a 2k-word memory that is accessable by the PDP 11/45, PDP 11/10, and special hardware that handles serial words between the PDP-11/45 and the NWDC. Words to be sent to the NWDC are kept and updated in a linked list by the PDP 11/45 or the PDP 11/10. This hardware reads the linked list from each channel and continuously sends the words to the NWDC. Words coming from the NWDC to the PDP 11/45 are placed in the common memory by adding the address sent with each word to the base address of that channel. Figure B-3 shows a block diagram of the serial word interfaces and common memory.

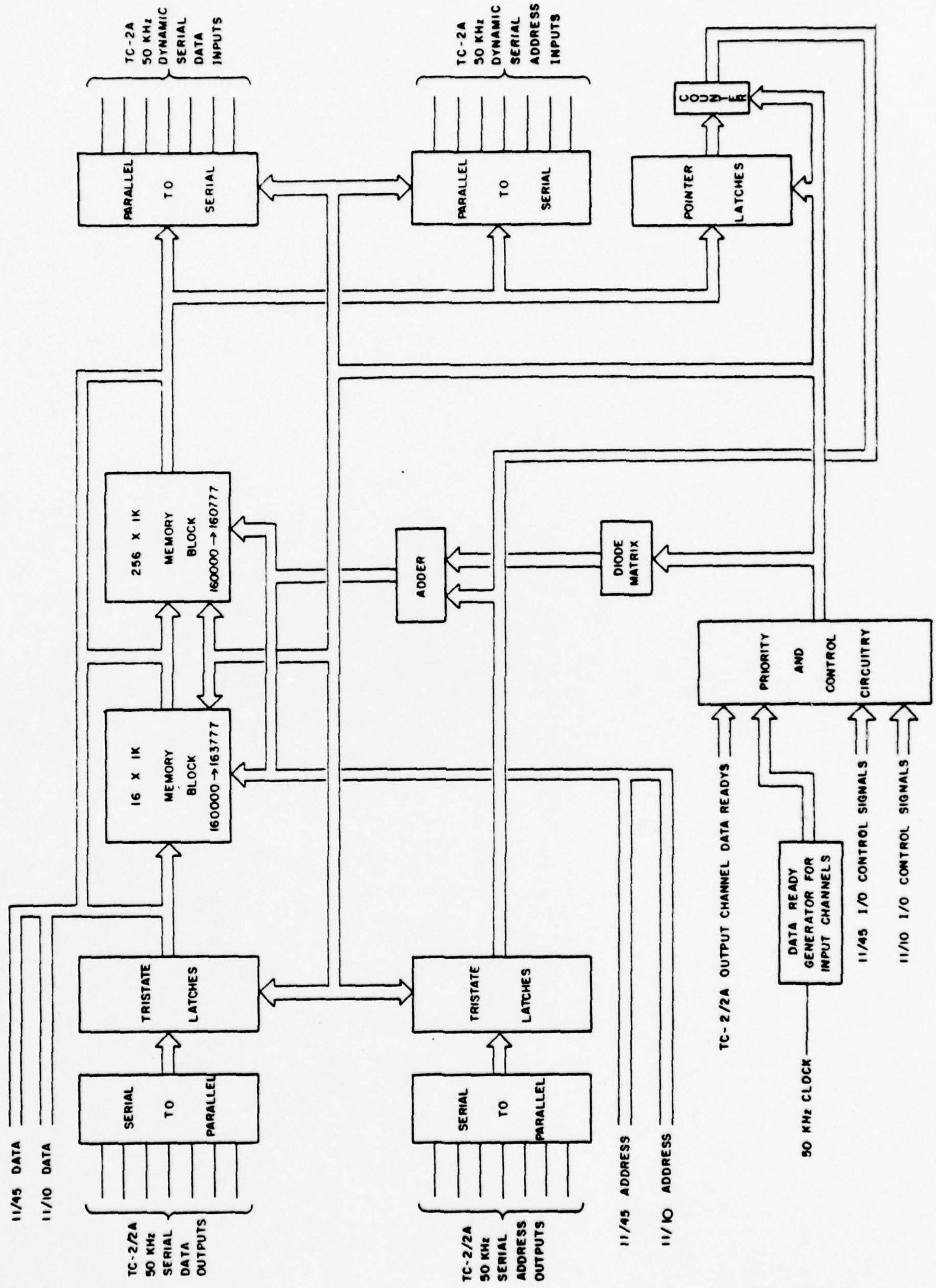

FIGURE B-3. Serial Word Interface and Common Memory.

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SOFTWARE DEVELOPMENT TEST STATION (SDTS)

In the WepSIL, the SDTS is a second generation unit which monitors and controls the bus of an avionics computer. It consists of a special interface between the A-7E ports of the TC-2/2A and a PDP 11/05 minicomputer. A floppy disk, mass storage, system is interfaced with the minicomputer, and is used to load software into both the PDP 11/05 and the TC-2/2A computers. For monitoring and control functions, the SDTS is equipped with a Cathode Ray Tube (CRT) terminal with a keyboard and also has a high speed paper tape reader. Figure B-4 is a block diagram of the SDTS system.

This hardware interface allows the PDP 11/05 to monitor activity on the internal bus of the TC-2/2A and to keep copies of the major registers of the TC-2/2A. The contents of these registers may be transferred to the PDP 11/05 at any time without halting the TC-2/2A. It also controls the TC-2/2A by stopping the Central Processing Unit (CPU) and stepping through instructions, thereby forcing data on the internal bus.

By using the appropriate key command, the operator can perform any of the following tasks:

1. Display any location or group of locations within the TC-2/2A's memory.

2. Load values into any location within the TC-2/2A memory.

3. Stop on compare on data or instructions in the TC-2/2A.

4. Display on compare the A, Q & IC registers and the SAR and SBR.

5. Load full loads or handloads from floppy disk or paper tape.

6. Make arithmetic or trigonometric calculations in any mixture of three bases (octal, decimal or hexidecimal), with fixed or floating point.

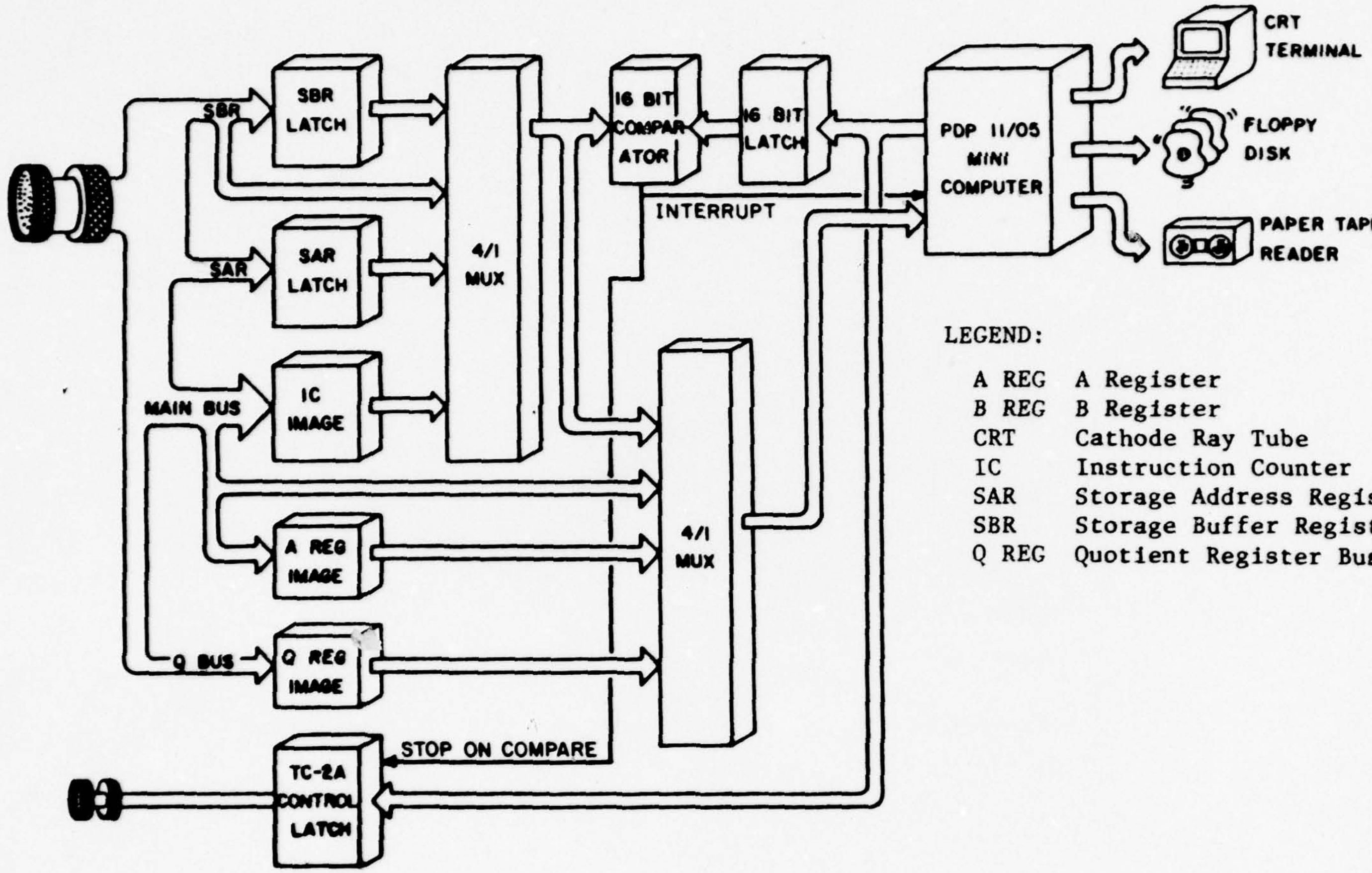
7. Search memory for certain "set bit" patterns.

8. Start and stop the TC-2/2A on command.

9. Display the full set of commands available.

10. Display directory of floppy disk.

11. Step through the TC-2/2A program, one instruction at a time, observing each register at each step.



LEGEND:

A REG	A Register
B REG	B Register
CRT	Cathode Ray Tube
IC	Instruction Counter
SAR	Storage Address Register
SBR	Storage Buffer Register
Q REG	Quotient Register Bus

FIGURE B-4. Software Development Test Station.

Appendix C

TEST PROCEDURES AND DATA SAMPLES

Various tests performed on the TC-2A computers (Serial Numbers JBB002 and JBB003) are described in this appendix in detail. Samples of data gathered during each test are also given. Care has been taken to select a representated cross section of the data gathered. The order followed is that of Table 3 of the main text, treating the analog signals first, then the digital signals. There is also a summary which includes tests made in an actual A-7E aircraft.

Each table of test results for both TC-2A computers lists the corresponding values for JBB003 in parentheses immediately following the values for JBB002.

ANALOG SIGNALS

DC Out

Five tests were performed on the analog DC-out signals for error, settling time, crosstalk, droop rate, drive and regulation. These are discussed in the order given with results following a brief description of the method used:

1. Error

   The OFP was modified to output selected values on each of four channels. Each channel was driven to full scale, half scale, quarter scale, and one bit. Measurements were made with a high accuracy digital voltmeter to ensure that all values were within ±0.5 percent of the selected values as calculated below:

$$\% \text{ error} = \frac{(\text{selected value - measured value})}{(\text{full range value})} \times 100$$

   Table C-1 tabulates the results for steering error, flight path, spare, and ground track channels.

2. Settling Time

   The OFP was modified so that the DC outputs would successively be 0 volts, 1/2 maximum positive and 1/2 maximum negative. The output of each channel was monitored to determine the time required for ringing to drop below .05 volts. Table C-2 shows these results.

TABLE C-1. Error in DC-Out Tests.

Channel	Selected value	Measured value (Vdc)		% error	
Steering Error ±4 Volt	+4 V	+3.999	(+3.991)	0.025	(0.225)
	+2 V	+1.999	(+1.995)	0.05	(0.250)
	+1 V	+1.000	(+0.996)	0.	(0.40)
	1 BIT = .0039 V	+0.006	(+0.005)		
	-4 V	-3.996	(-4.000)	0.10	(0.)
	-2 V	-1.997	(-2.000)	0.15	(0.)
	-1 V	-0.9976	(-1.001)	0.24	(0.100)
	1 BIT = -.0039 V	-0.0021	(-0.002)		
Flight Path ±18 V	+18 V	+17.89	(+17.964)	0.61	(0.200)
	+9 V	+8.931	(+8.972)	0.77	(0.311)
	+4.5 V	+4.451	(+4.490)	1.10	(0.222)
	+1 BIT = .0176 V	-0.002	(+.0241)		
	-18 V	-17.97	(-18.008)	0.16	(0.044)
	-9 V	-9.019	(-9.015)	0.21	(0.167)
	-4.5 V	-4.535	(-4.514)	0.77	(0.311)
	1 BIT = -.0176 V	-0.0565	(-.0134)		
Spare ±18 Volt	+18 V	+17.97	(+17.88)	0.16	(0.667)
	+9 V	+8.930	(+8.999)	0.22	(0.011)
	+4.5 V	+4.497	(+4.501)	0.07	(0.022)
	+1 BIT = .0176 V	+0.0295	(+.0398)		
	-18 V	-17.99	(-18.00)	0.06	(0.)
	-9 V	-9.020	(-8.98)	0.22	(0.222)
	-4.5 V	-4.535	(-4.50)	0.77	(0.)
	-1 BIT = -.0176 V	-0.0565	(-.0027)		
Ground Track 0-18 Volt	+18 V	+17.974	(+17.964)	0.14	(0.20)
	+9 V	+8.988	(+8.980)	0.13	(0.22)
	+4.5 V	+4.493	(+4.487)	0.15	(0.245)
	+1 BIT = .0176 V	+0.030	(+0.027)		

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TABLE C-2. Settling Time in DC-Out Tests.

Channel	Settling time
±18 Volt spare	Transition time 10 μsec No measurable ringing or overshoot
0 - 18 volts	Perfect square wave, no ringing or settling time
±4 volts	Same

3. Crosstalk

The OFP was modified, via a hand load, to output varying voltages on a selected channel while all other channels were held constant. The constant channels were monitored to determine if any voltage variations occurred as a result of voltage variation in the selected channel.

Table C-3 shows the results.

TABLE C-3. Crosstalk in DC-Out Tests.

Selected channel	Constant channels	Voltage variations (500 mV scale)
±18 Volt spare	±18 V flight path	none measurable
	±4 V steering error	none measurable
	0 - 18 V ground track	none measurable

4. Droop Rate

The direct current outputs of the steering error channel (±4 volt), the ground track channel (0 - 18 volt) and flight path channel were set for full scale. The computer was then halted.

For both computers no measureable change occurred.

5. Drive and Regulation

With the DC outputs set for full scale, output channels were connected to variable resistive loads and the load was varied from no load to full rated load.

Voltage regulation was monitored with the resistive loading shown in Table C-4.

TABLE C-4. Drive and Regulation in DC-Out Tests.

Channel	Voltage reading				Regulation (%)	
±18 volts Flight path, 1kΩ	+17.89 -17.97	+17.87 -17.95	(+17.98) (-18.02)	(+17.96) (-18.01)	99.8 99.4	(99.9) (99.9)
±18 volt Spare, 1kΩ	+18.08 -17.96	+17.98 -17.94	(+18.00) (-17.99)	(17.98) (-17.97	99.4 99.9	(99.8) (99.8)
±4 volt Steering error, 1kΩ	+3.999 -3.997	+3.996 -3.713	(+3.996) (-4.002)	(3.993) (-3.999)	99.9 92.9	(99.9) (99.9)
0 - 18 volt Ground track 10kΩ	+17.974	+17.973	(17.97)	(+17.97)	99.8	(100)
AC Channel Spare, 10kΩ			(11.99)	(11.99)		(100)

DC In

The direct-current-in signals were tested for three parameters: conversion time, conversion error and ratiometric error:

1. Conversion Time

The elapsed time for both computers included the times for both the instruction code and the internal cycle, although the output may not have completely stabilized.

The time measured for each TC-2A was 325 μsec.

2. Conversion Error

The analog-to-digital conversion error was measured by reading the direct current voltages from the panel potentiometers and the contents of the accumulator at the normal conversion point in the OFP with the potentiometers set at full and at half. This procedure was repeated for each of the six lines shown in the table representing the data gathered.

The results are shown in Table C-5.

3. Ratiometric Error

The reference voltage and the wiper output were measured for each of the five analog input potentiometers, as well as measuring the two Bullpup controller inputs.

The measured values were compared against the computer readout as shown in Table C-6.

The percent error was computed by the following equation:

$$\%\ \text{error} = \frac{\left(\dfrac{\text{Measured value}}{\text{Reference signal}} \times \text{maximum digital}_{10}\right) - \text{Computer readout}_{10}}{\text{Reference signal}}$$

Synchro Out

The four standard output synchros of the TC-2A (magnetic heading, true heading, pitch and roll) were tested in the following areas: absolute error, crosstalk, jitter and conversion time.

1. Absolute Error

Synchro-out error was measured by connecting an accurate 16-bit DDC model Series A synchro-to-digital (S/D) converter between the TC-2A synchro output and the input of the PDP 11/45. Not only does the PDP control the angles to be sent by the TC-2A, but also has a special subroutine that steps through the four synchro output channels. The OFP was modified so that a digital word sent by the PDP 11/45 on the serial word channel is converted by the TC-2A to synchro form and sent back on the synchro channel, through the S/D converter once every cycle (25 times per second). The PDP 11/45 compares the angle returned with the angle it sent, and records the maximum and minimum error for each of over 200 readings for each angle, starting at 0 degree and incrementing by 0.1 degree.

TABLE C-5. DC-In Analog-To-Digital Conversion Error.

Channel	Actual Input Voltage		Digital Readout		Converted Value	
Radar Alt	25.00	(25.00)	7FF8	(7FF8)	25.000	(25.000)
	12.50	(12.50)	4000	(4010)	12.500	(12.515)
TAS	3.962	(3.99)	7FE8	(7FF0)	3.998	(3.999)
	2.002	(2.00)	4128	(4030)	2.039	(2.006)
Baro Alt	3.962	(3.98)	7FF0	(7FF0)	3.999	(3.999)
	2.000	(2.00)	4120	(40A8)	2.037	(2.021)
Mach No.	3.963	(3.99)	7FF0	(7FF0)	3.999	(3.998)
	2.000	(2.00)	4140	(4020)	2.040	(2.004)
AOA	3.963	(3.99)	7FE8	(7FF8)	3.998	(4.000)
	2.000	(2.00)	4120	(4020)	2.037	(2.004)
Bullpup UP/DN	+3.960	(±4/+3.96)	7FA0	(7FE0)	3.989	(3.991)
	-4.032	(-4.00)	8008	(8080)	3.999	(3.980)
Control LF/RT	+3.961	(±4/+3.96)	7FE0	(7FD8)	3.997	(3.996)
	-4.032	(-4.00)	8008	(8088)	3.999	(3.983)

TABLE C-6. DC-In Ratiometric Error.

Channel		Reference Signal (volts)		Measured Value (volts)		Computer Readout		Converted Readout		Percent	
Radar Alt		27.15	(26.97)	13.50	(13.50)	4500	(4518)	13.63	(13.5)	4	(4)
TAS		3.996	(3.960)	2.000	(2.000)	3FE8	(4130)	1.99	(2.037)	.30	(.42)
Baro Alt		3.996	(3.960)	2.000	(2.000)	3FE8	(4100)	1.99	(2.031)	.30	(.27)
Mach No.		3.995	(3.962)	2.000	(2.000)	3FD0	(4140)	1.99	(2.040)	.31	(.52)
AOA		3.996	(3.960)	2.000	(2.000)	3FF0	(40E7)	2.00	(2.028)	.05	(.19)
Bullpup Control	UP	+4.002	(+3.963)	1.995	(2.000)	4010	(4140)	2.00	(2.039)	.15	(.48)
	DN	-3.997	(-4.036)	-2.004	(-2.000)	C018	(C138)	-1.995	(-1.961)	.26	(.53)
	LF	+4.002	(+3.963)	2.000	(2.003)	3FF0	(4248)	2.00	(2.040)	.02	(.46)
	RT	-3.997	(-4.036)	-2.007	(-2.001)	C060	(C120)	-1.98	(-1.964)	.71	(.48)

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After the tests were run, the data were checked to verify that no angle deviated from the set angle by more than ±6 minutes. As shown in Table C-7, a small sample selected from the pitch data, the deviation did not exceed four minutes.

2. Crosstalk

The hardware configuration used for this test was the same as for the synchro error tests. The PDP 11/45 program was conditioned to hold constant the synchro being monitored and to send a changing pattern to the other three TC-2/A synchro-out channels. The data from the monitored channel was analyzed to ascertain if any noticeable correlation between the values on the varying synchros and the values on the monitored channel was present.

There was no measureable crosstalk.

3. Jitter

The data on jitter were gathered in the synchro-out absolute error test.

The jitter was found to be within specification.

4. Conversion Time

The measurement was made to determine how long the CPU to signal converter interface was involved in the conversion (how long from the time one conversion is started until the next one may be started).

The TC-2A was programmed to set a selected discrete output at the start of a conversion cycle and reset it when the conversion complete interrupt appeared in the TC-2A.

The conversion time was measured indirectly by measuring the set/reset time of the discrete.

The set/reset time of the discrete was 20 μsec, which was well under the specified time.

Synchro In

Synchro-in was tested thoroughly because of problems encountered with the preproduction TC-2As. The areas of concern were: conversion error, jitter, input impedance and conversion time.

TABLE C-7. Synchro-Out Pitch Angles Conversion Error.

ANGLE (DEG.)	HI (DEG.)	LOW (DEG.)	MAX CHANGE (MIN.)	MAX DELTA (MIN.)	MAX POS DEV.	MAX NEG DEV.
0.0909	0.1044	0.0714	1.9776	1.9776	0.3297	-1.6480
0.1978	0.2362	0.1813	3.2959	1.9776	2.3072	-0.9888
0.2966	0.3021	0.2637	2.3072	2.3072	0.3296	-1.9776
0.3955	0.4175	0.3735	2.6368	2.3072	1.3184	-1.3184
0.4999	0.5054	0.4614	2.6368	1.6480	0.3296	-2.3072
0.5988	0.6427	0.5988	2.6368	1.9776	2.6368	0.0000
0.6976	0.7251	0.6867	2.3072	2.3072	1.6480	-0.6592
0.7965	0.8295	0.8075	1.3184	0.6592	1.9776	0.0000
0.8954	0.9174	0.8515	3.9551	1.9776	1.3184	-2.6368
0.9998	1.0163	0.9613	3.2959	2.3072	0.9888	-2.3072
1.0986	1.1371	1.0602	4.6143	1.9776	2.3072	-2.3072
1.1975	1.2250	1.1536	4.2847	1.6480	1.6480	-2.6368
1.2964	1.3129	1.2580	3.2959	2.3072	0.9888	-2.3072
1.3953	1.4282	1.3513	4.6143	2.3072	1.9776	-2.6368
1.4997	1.5051	1.4722	1.9776	1.3184	0.3296	-1.6480
1.5985	1.6205	1.5491	4.2847	1.9776	1.3184	-2.9664
1.6974	1.7359	1.6974	2.3072	1.6480	2.3072	0.0000
1.7963	1.8293	1.7578	4.2847	2.6368	1.9776	-2.3072
1.8952	1.9336	1.8952	2.3072	1.6480	2.3072	0.0000
1.9995	2.0380	2.0050	1.9776	1.6480	2.3072	0.0000
2.0984	2.1204	2.0874	1.9776	1.9776	1.3184	-0.6592
2.1973	2.2358	2.1588	4.6143	1.6480	2.3072	-2.3072
2.2962	2.2907	2.2467	2.6368	1.9776	0.0000	-2.9664
2.3951	2.4060	2.8621	2.6368	2.3072	0.6592	-1.9776
2.4994	2.4994	2.4500	2.9664	2.3072	0.0000	-2.9664
2.5983	2.6368	2.5658	4.2847	2.3072	2.3072	-1.9776
2.6972	2.7137	2.6532	3.6255	2.3072	0.9888	-2.6368
2.7961	2.8290	2.7961	1.9776	1.9776	1.9776	0.0000
2.8949	2.9279	2.8785	2.9664	1.9776	1.9776	-0.9883
2.9993	3.0268	3.9828	2.6368	1.6480	1.6480	-0.9888
3.0982	3.1312	3.0927	2.3072	1.6480	1.9776	-0.3296
3.1971	3.2245	3.1916	1.9776	1.9776	1.6480	-0.3296
3.2959	3.3344	3.2630	4.2847	2.9664	2.3072	-1.9776
3.3948	3.4003	3.3509	2.9664	1.9776	0.3296	-2.6368
3.4992	3.5157	3.4662	2.9664	1.9776	0.9888	-1.9776
3.5981	3.6255	3.5541	4.2847	1.9776	1.6480	-2.6368
3.6970	3.7299	3.6585	4.2847	1.3184	1.9776	-2.3072
3.7958	3.8013	3.7574	2.6368	2.3072	0.3296	-2.3072
3.8947	3.9387	3.8947	2.6368	2.3072	2.6368	0.0000
3.9991	4.0101	3.9716	2.3072	1.3184	0.6592	-1.6480
4.0980	4.1035	4.0540	2.9664	2.3072	0.3296	-2.6368
4.1968	4.2463	4.1639	4.9439	2.6368	2.9664	-1.9776
4.2957	4.3012	4.2518	2.9664	2.3072	0.3296	-2.6368
4.3946	4.4001	4.3561	2.6368	2.3072	0.3296	-2.3072
4.4990	4.4990	4.4550	2.6368	2.6368	0.0000	-2.6368
4.5978	4.6088	4.5649	2.6368	2.6368	0.6592	-1.9776
4.6967	4.7187	4.6473	4.2847	1.6480	1.3184	-2.9664
4.7956	4.8286	4.7572	4.2847	2.3072	1.9776	-2.3072
4.9000	4.9384	4.8945	2.6368	2.6368	2.3072	-0.3296
4.9989	5.0263	4.9879	2.3072	1.3184	1.6480	-0.6592
5.0977	5.1087	5.0593	3.9664	1.6480	0.6592	-2.3072

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1. Conversion Error

The process of measuring error for synchro-in is similar to that for synchro-out. The OFP of the TC-2A was modified so that after it converted the four analog signals it received from the WepSIL synchro box, it would feed them back in digital form to the PDP 11/45 over the flight recorder channel. The PDP 11/45 then compared them with the digital data it originally sent to the synchro box. The signals of interest are pitch, roll, true heading and magnetic heading. Table C-8 shows a small sample selected from the pitch data of 105 degrees.

The SYNTN program of the PDP 11/45 controls the test of the TC-2A's accuracy of converting analog (synchro) to digital signals as follows:

a. The PDP 11/45 sets the angle for the test channel.

b. To allow for synchro settling, the PDP 11/45 waits 75 40-ms cycles before reading data it receives back from the TC-2A.

c. The PDP 11/45 makes 200 readings, one in each 40-ms cycle. The flight recorder channel is used to transmit the data between the two computers. The data are recorded, calculated and stored in memory.

d. At the end of 200 readings, the angle is incremented by a tenth of a degree and steps b through d are repeated until 360 degrees have been sampled.

e. At request, the 11/45 prints out a partial listing of a run on pitch angles as given in Table C-8. No angle deviated from the base angle by more than ±4 minutes.

2. Jitter

To measure synchro-in jitter, a test program for the PDP 11/45 was used to drive the synchros of the tactical computer and print out data resulting from the tests. The purpose of this program was to gather data on the amount of jitter its synchro inputs produced in the TC-2A and by the synchros themselves as well as the amount of error present. The method in which the program performs its tasks follows:

a. The PDP 11/45 software sets up an initial angle on each of the four synchro channels. After a waiting period or 75 40-ms cycles, one channel is varied in five-degree

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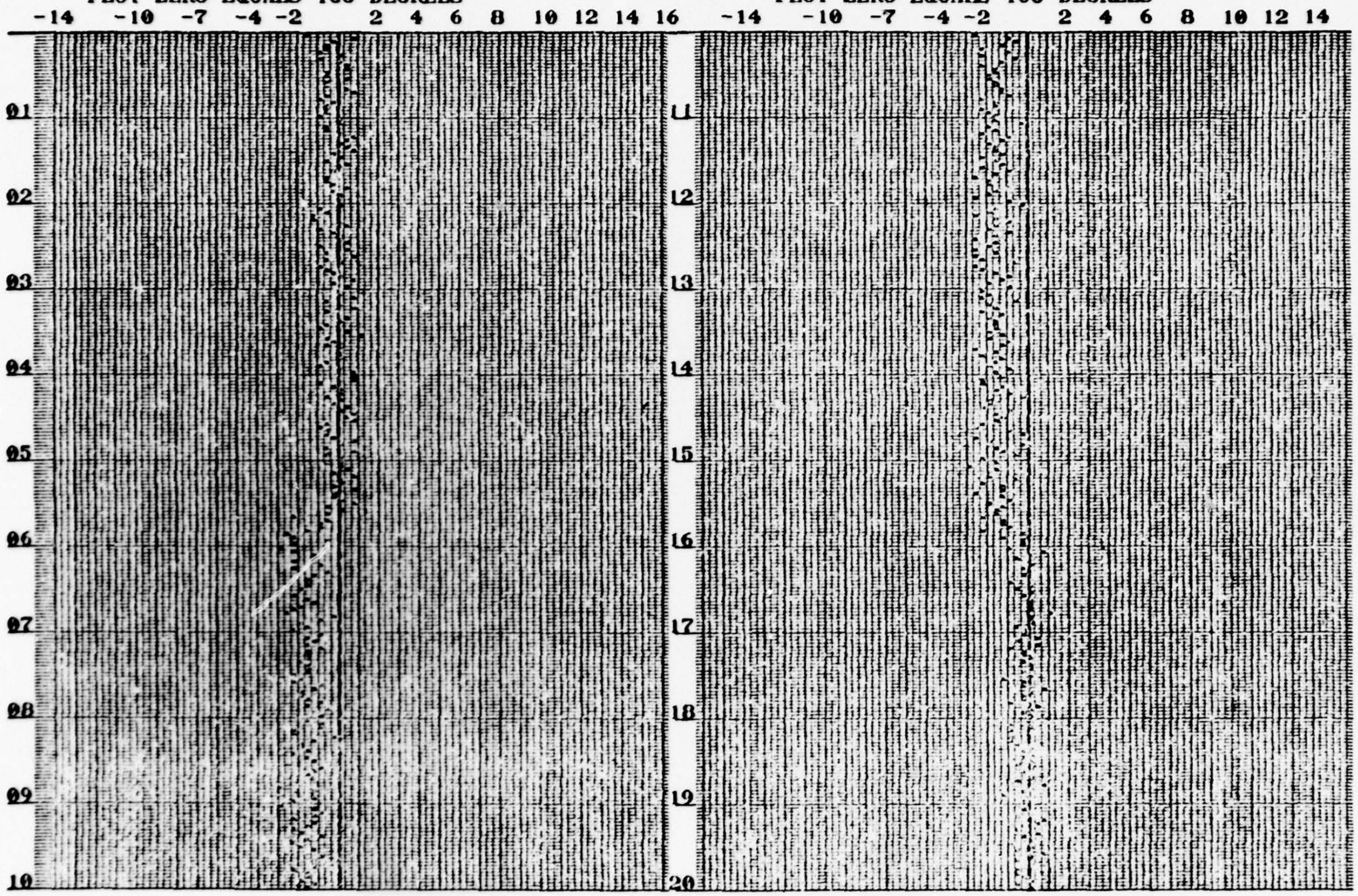
TABLE C-8. Sample Data for Synchro-In Absolute Error.

FILE-MT0:GTH701.PIT TC2A76:JBB002
1-JUL-77 PITCH AT 105 DEGREES.

PAGE 0 FILE: MT0:GTH701.PIT
DOWN THE PAGE: UNITS ARE IN SECONDS------- ACROSS THE PAGE: UNITS ARE IN MINUTES
PLOT ZERO EQUALS 105 DEGREES PLOT ZERO EQUALS 105 DEGREES



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increments while the other three are held constant at their initial value.

b. After the synchros of the TC-2A have settled, the PDP 11/45 reads 2,000 40-ms cycles for each setting. The data are returned by the TC-2A via the flight recorder channel. The PDP 11/45 calculates the jitter by comparing each reading with its predecessor, producing a delta value which is expressed in half arc minutes. At the same time, the PDP 11/45 calculates the error between the present reading and the output value, expressed in deltas.

c. After each group of 2,000 readings, the program increments the variable channel by five degrees. This loop is repeated 72 times, until 360 degrees have been covered.

d. After the jitter calculations over the 360 degrees have been completed, the PDP 11/45 prints out the information gathered.

Tables C-9 through C-12 are typical examples of printouts from one test run showing the jitter spread in deltas for each angle in each synchro channel of the TC-2A. There is also a weighted and a maximum delta value. The weighted value represents the sum of the number of deltas within a certain half-minute deviation multiplied by its number of half-minute deviations from zero. These four tables are concerned with the synchro channels for pitch, roll, magnetic heading and true heading, respectively.

Table C-13 is a printout of a composite of the weighted values for all four channels of Tables C-9 through C-12. In addition, Tables C-14 through C-17 are printouts showing the positive and negative excursions of error for each angle of each of the same four synchro channels.

Much earlier, as can be seen by the dates on the printouts, these synchro-in jitter tests had been run on a standard TC-2 and also on the preproduction units of the TC-2A. In each of these instances, data were taken for three rather than four channels. To minimize the bulk of data presented here, only one typical data sample has been selected from the printouts for the TC-2 and the preproduction TC-2As. Comparision of these data to that of Table C-9 will show the problems with the preproduction units that were later corrected. The selected data for the TC-2 and preproduction TC-2A are contained in Tables C-18 and C-19 respectively.

TABLE C-9. Synchro-In Jitter Data on Pitch Channel.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

PITCH INPUT ANGLES (FIRST COLUMN) VRS DELTA CONCENTRATION (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading= 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIAION WEIGHTED VALUE AND MAX DELTA ARE LAST TWO COLUMNS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	WTVL	MXDELT
5	811	911	0	276	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1751.0	7
10	887	920	0	188	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1509.0	5
15	819	940	0	239	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1667.0	5
20	843	939	0	214	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	1603.0	7
25	833	948	0	211	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	1629.0	7
30	914	911	0	167	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0	1456.0	7
35	841	930	0	224	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1627.0	5
40	802	957	0	236	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1690.0	5
45	885	875	0	238	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1599.0	5
50	833	943	0	223	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1617.0	5
55	869	879	0	243	0	7	0	2	0	0	0	0	0	0	0	0	0	0	0	1657.0	7
60	832	930	0	237	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1646.0	5
65	768	945	0	281	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1818.0	5
70	809	915	0	274	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1747.0	5
75	800	943	0	257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1714.0	3
80	793	959	0	239	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	1721.0	5
85	890	887	0	217	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	1574.0	7
90	917	915	0	165	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1427.0	7
95	934	919	0	142	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	1374.0	7
100	889	922	0	183	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1501.0	5
105	781	922	0	293	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	1823.0	7
110	894	950	0	148	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	1436.0	7
115	806	926	0	266	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1734.0	5
120	813	971	0	211	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	1631.0	7
125	872	960	0	164	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	1476.0	7
130	765	972	0	263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1761.0	3
135	770	984	0	243	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1728.0	5
140	879	924	0	191	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	1533.0	7
145	790	956	0	251	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1724.0	5
150	749	897	0	349	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	1973.0	7
155	866	912	0	221	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1580.0	5
160	820	890	0	288	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1764.0	5
165	846	873	0	278	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1722.0	5
170	821	895	0	280	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1755.0	5
175	813	922	0	263	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1721.0	5
180	750	914	0	335	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1926.0	7
185	964	923	0	111	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1266.0	5
190	868	913	0	218	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1572.0	5
195	826	912	0	258	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1706.0	5
200	767	915	0	316	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1873.0	5
205	870	924	0	204	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1548.0	7
210	715	845	0	440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2165.0	3
215	815	898	0	286	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1761.0	5
220	769	915	0	314	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1867.0	5
225	732	893	0	373	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2022.0	5
230	810	911	0	274	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1758.0	5
235	702	928	0	367	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2044.0	5
240	733	934	0	331	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1939.0	7
245	811	909	0	278	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1753.0	5
250	801	914	0	285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1769.0	3
255	820	909	0	269	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1728.0	7
260	656	912	0	431	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2210.0	5
265	764	916	0	318	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1880.0	5
270	775	919	0	305	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1839.0	5
275	780	942	0	274	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	1788.0	7
280	798	940	0	259	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1732.0	5
285	809	884	0	304	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1811.0	5
290	787	941	0	264	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0	1777.0	7
295	807	943	0	246	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1701.0	5
300	753	941	0	304	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1863.0	5
305	782	942	0	274	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1774.0	5
310	790	943	0	261	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	1758.0	7
315	857	950	0	188	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	1543.0	7
320	801	933	0	263	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1737.0	5
325	867	908	0	221	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1591.0	5
330	865	929	0	202	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1555.0	5
335	824	931	0	244	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1668.0	5
340	871	891	0	233	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1615.0	5
345	814	941	0	237	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0	1696.0	7
350	881	912	0	204	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1539.0	5
355	766	900	0	329	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	1914.0	7
360	937	931	0	130	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1333.0	7

JITTER TEST---EACH DELTA=PRESENT READING-LAST READING.

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TABLE C-10. Synchro-In Jitter Data on Roll Channel.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

ROLL INPUT ANGLES (FIRST COLUMN) VRS DELTA CONCENTRATION (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading= 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIAION WEIGHTED VALUE AND MAX DELTA ARE LAST TWO COLUMNS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	WTVL	MXDELT
5	1010	897	0	64	0	26	0	3	0	0	0	0	0	0	0	0	0	0	0	1240.0	7
10	1107	782	0	75	0	29	0	7	0	0	0	0	0	0	0	0	0	0	0	1201.0	7
15	966	903	0	91	0	30	0	5	0	0	0	0	0	0	0	0	0	0	0	1366.0	7
20	1013	855	0	101	0	25	0	6	0	0	0	0	0	0	0	0	0	0	0	1325.0	7
25	1043	831	0	84	0	36	0	6	0	0	0	0	0	0	0	0	0	0	0	1305.0	7
30	1217	666	0	58	0	47	0	12	0	0	0	0	0	0	0	0	0	0	0	1159.0	7
35	1038	837	0	77	0	42	0	6	0	0	0	0	0	0	0	0	0	0	0	1320.0	7
40	1034	850	0	58	0	31	0	7	0	0	0	0	0	0	0	0	0	0	0	1228.0	7
45	1070	825	0	76	0	27	0	2	0	0	0	0	0	0	0	0	0	0	0	1202.0	7
50	1079	786	0	88	0	44	0	3	0	0	0	0	0	0	0	0	0	0	0	1291.0	7
55	1092	791	0	70	0	41	0	6	0	0	0	0	0	0	0	0	0	0	0	1248.0	7
60	1030	824	0	99	0	25	0	2	0	0	0	0	0	0	0	0	0	0	0	1260.0	7
65	980	882	0	117	0	19	0	2	0	0	0	0	0	0	0	0	0	0	0	1342.0	7
70	958	914	0	98	0	26	0	4	0	0	0	0	0	0	0	0	0	0	0	1366.0	7
75	997	870	0	105	0	23	0	5	0	0	0	0	0	0	0	0	0	0	0	1335.0	7
80	1043	834	0	94	0	25	0	4	0	0	0	0	0	0	0	0	0	0	0	1269.0	7
85	1013	879	0	79	0	19	0	5	0	0	0	0	0	0	0	0	0	0	0	1246.0	7
90	1126	772	0	57	0	40	0	5	0	0	0	0	0	0	0	0	0	0	0	1178.0	7
95	1103	799	0	58	0	29	0	11	0	0	0	0	0	0	0	0	0	0	0	1195.0	7
100	1073	818	0	75	0	29	0	5	0	0	0	0	0	0	0	0	0	0	0	1223.0	7
105	995	894	0	84	0	24	0	3	0	0	0	0	0	0	0	0	0	0	0	1287.0	7
110	1128	759	0	59	0	50	0	4	0	0	0	0	0	0	0	0	0	0	0	1214.0	7
115	1009	867	0	86	0	28	0	10	0	0	0	0	0	0	0	0	0	0	0	1335.0	7
120	1055	810	0	81	0	48	0	6	0	0	0	0	0	0	0	0	0	0	0	1335.0	7
125	1096	767	0	78	0	45	0	14	0	0	0	0	0	0	0	0	0	0	0	1324.0	7
130	1022	879	0	76	0	21	0	2	0	0	0	0	0	0	0	0	0	0	0	1226.0	7
135	1035	852	0	88	0	19	0	5	0	1	0	0	0	0	0	0	0	0	0	1255.0	9
140	1104	774	0	79	0	37	0	6	0	0	0	0	0	0	0	0	0	0	0	1238.0	7
145	996	857	0	117	0	27	0	3	0	0	0	0	0	0	0	0	0	0	0	1364.0	7
150	973	904	0	102	0	18	0	3	0	0	0	0	0	0	0	0	0	0	0	1321.0	7
155	1064	803	0	93	0	34	0	6	0	0	0	0	0	0	0	0	0	0	0	1294.0	7
160	1019	882	0	76	0	19	0	4	0	0	0	0	0	0	0	0	0	0	0	1283.0	7
165	1091	814	0	78	0	13	0	4	0	0	0	0	0	0	0	0	0	0	0	1141.0	7
170	1006	862	0	100	0	34	0	4	0	0	0	0	0	0	0	0	0	0	0	1360.0	7
175	1043	857	0	67	0	27	0	6	0	0	0	0	0	0	0	0	0	0	0	1235.0	7
180	916	954	0	115	0	12	0	3	0	0	0	0	0	0	0	0	0	0	0	1380.0	7
185	1217	684	0	63	0	28	0	8	0	0	0	0	0	0	0	0	0	0	0	1069.0	7
190	1052	843	0	73	0	27	0	4	0	1	0	0	0	0	0	0	0	0	0	1234.0	9
195	1004	872	0	83	0	25	0	11	0	0	0	0	0	0	0	0	0	0	0	1338.0	7
200	1030	858	0	91	0	18	0	3	0	0	0	0	0	0	0	0	0	0	0	1242.0	7
205	1132	783	0	60	0	21	0	4	0	0	0	0	0	0	0	0	0	0	0	1096.0	7
210	958	927	0	106	0	5	0	4	0	0	0	0	0	0	0	0	0	0	0	1298.0	7
215	1013	878	0	87	0	18	0	4	0	0	0	0	0	0	0	0	0	0	0	1257.0	7
220	1049	820	0	112	0	17	0	2	0	0	0	0	0	0	0	0	0	0	0	1255.0	7
225	967	906	0	121	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1299.0	5
230	1065	815	0	96	0	22	0	2	0	0	0	0	0	0	0	0	0	0	0	1227.0	7
235	913	957	0	116	0	10	0	4	0	0	0	0	0	0	0	0	0	0	0	1383.0	7
240	996	887	0	105	0	10	0	2	0	0	0	0	0	0	0	0	0	0	0	1266.0	7
245	1042	843	0	83	0	23	0	3	0	0	0	0	0	0	0	0	0	0	0	1228.0	7
250	1004	880	0	102	0	9	0	5	0	0	0	0	0	0	0	0	0	0	0	1266.0	7
255	1028	845	0	106	0	15	0	6	0	0	0	0	0	0	0	0	0	0	0	1280.0	7
260	904	966	0	121	0	8	0	1	0	0	0	0	0	0	0	0	0	0	0	1376.0	7
265	1003	877	0	94	0	23	0	3	0	0	0	0	0	0	0	0	0	0	0	1295.0	7
270	982	931	0	74	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	1218.0	5
275	982	890	0	96	0	25	0	7	0	0	0	0	0	0	0	0	0	0	0	1352.0	7
280	1000	874	0	96	0	23	0	7	0	0	0	0	0	0	0	0	0	0	0	1326.0	7
285	1050	854	0	83	0	11	0	2	0	0	0	0	0	0	0	0	0	0	0	1172.0	7
290	1079	814	0	75	0	29	0	3	0	0	0	0	0	0	0	0	0	0	0	1205.0	7
295	1024	864	0	89	0	19	0	4	0	0	0	0	0	0	0	0	0	0	0	1254.0	7
300	976	904	0	95	0	22	0	3	0	0	0	0	0	0	0	0	0	0	0	1320.0	7
305	1109	780	0	87	0	18	0	6	0	0	0	0	0	0	0	0	0	0	0	1173.0	7
310	1043	831	0	87	0	33	0	3	0	1	0	0	0	0	0	0	0	0	0	1287.0	9
315	1086	812	0	62	0	30	0	10	0	0	0	0	0	0	0	0	0	0	0	1218.0	7
320	982	906	0	92	0	16	0	4	0	0	0	0	0	0	0	0	0	0	0	1290.0	7
325	1067	821	0	82	0	27	0	3	0	0	0	0	0	0	0	0	0	0	0	1223.0	7
330	1131	756	0	86	0	22	0	5	0	0	0	0	0	0	0	0	0	0	0	1159.0	7
335	1052	816	0	97	0	30	0	5	0	0	0	0	0	0	0	0	0	0	0	1292.0	7
340	1034	852	0	82	0	28	0	4	0	0	0	0	0	0	0	0	0	0	0	1266.0	7
345	1053	802	0	92	0	48	0	4	0	1	0	0	0	0	0	0	0	0	0	1355.0	9
350	1072	805	0	80	0	38	0	5	0	0	0	0	0	0	0	0	0	0	0	1270.0	7
355	1037	848	0	92	0	19	0	4	0	0	0	0	0	0	0	0	0	0	0	1247.0	7
360	1122	766	0	60	0	46	0	6	0	0	0	0	0	0	0	0	0	0	0	1218.0	7

JITTER TEST---EACH DELTA=PRESENT READING-LAST READING.

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TABLE C-11. Synchro-In Jitter Data on Magnetic Heading Channel.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

MAG INPUT ANGLES (FIRST COLUMN) VRS DELTA CONCENTRATION (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading= 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIAION WEIGHTED VALUE AND MAX DELTA ARE LAST TWO COLUMNS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	WTVL	MXDELT
5	905	698	214	174	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1686.0	5
10	755	782	268	178	12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1925.0	5
15	807	803	207	164	15	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1789.0	5
20	746	764	301	170	13	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1958.0	5
25	823	862	162	142	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1661.0	5
30	822	871	153	138	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1663.0	5
35	813	769	204	193	16	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1845.0	5
40	824	828	190	155	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1685.0	4
45	733	905	269	72	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1743.0	4
50	915	762	186	127	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1557.0	5
55	920	781	151	132	13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1546.0	5
60	845	799	191	149	9	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1699.0	5
65	846	801	192	143	17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1688.0	6
70	816	798	248	128	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1719.0	5
75	824	877	171	121	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1612.0	5
80	738	812	229	190	20	11	0	0	0	0	0	0	0	0	0	0	0	0	0	1975.0	5
85	806	599	250	294	41	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2195.0	5
90	1212	517	0	128	90	53	0	0	0	0	0	0	0	0	0	0	0	0	0	1526.0	5
95	913	715	247	99	22	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1614.0	5
100	846	752	204	181	11	5	1	0	0	0	0	0	0	0	0	0	0	0	0	1778.0	6
105	849	848	172	124	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1593.0	5
110	836	759	184	198	18	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1818.0	5
115	860	738	230	148	19	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1743.0	5
120	813	791	207	151	23	13	1	1	0	0	0	0	0	0	0	0	0	0	0	1828.0	7
125	751	772	226	188	44	16	3	0	0	0	0	0	0	0	0	0	0	0	0	2062.0	6
130	820	789	200	159	24	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1802.0	5
135	686	733	202	327	42	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2336.0	5
140	818	751	202	199	20	8	1	1	0	0	0	0	0	0	0	0	0	0	0	1835.0	7
145	767	821	168	203	33	7	0	0	0	1	0	0	0	0	0	0	0	0	0	1942.0	9
150	861	720	276	127	11	3	2	0	0	0	0	0	0	0	0	0	0	0	0	1724.0	6
155	834	790	219	137	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1724.0	5
160	741	754	266	210	23	5	0	1	0	0	0	0	0	0	0	0	0	0	0	2046.0	7
165	783	720	240	232	21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2000.0	5
170	761	844	187	187	16	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1858.0	5
175	953	845	119	81	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1335.0	5
180	1321	637	5	30	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	776.0	7
185	941	514	204	302	31	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1992.0	5
190	788	747	233	210	15	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1938.0	5
195	847	780	201	162	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1709.0	5
200	796	731	240	211	17	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1937.0	5
205	782	768	240	190	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1898.0	4
210	848	671	361	99	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1774.0	4
215	886	855	115	133	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1532.0	5
220	813	788	230	143	20	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1787.0	5
225	747	925	87	217	22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1848.0	5
230	1150	584	162	86	16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1240.0	5
235	831	766	240	144	17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1756.0	5
240	875	752	241	120	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1643.0	5
245	802	730	232	201	27	8	0	0	0	0	0	0	0	0	0	0	0	0	0	1945.0	5
250	850	749	209	163	24	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1777.0	5
255	756	639	308	265	29	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2181.0	5
260	879	748	182	173	16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1705.0	5
265	918	812	161	96	7	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1480.0	5
270	1223	231	37	509	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1832.0	3
275	744	638	257	333	22	4	1	1	0	0	0	0	0	0	0	0	0	0	0	2272.0	7
280	772	807	217	173	22	9	0	0	0	0	0	0	0	0	0	0	0	0	0	1893.0	5
285	733	791	254	191	15	14	1	1	0	0	0	0	0	0	0	0	0	0	0	2015.0	7
290	716	719	260	256	38	8	1	2	0	0	0	0	0	0	0	0	0	0	0	2219.0	7
295	721	740	282	215	30	10	1	1	0	0	0	0	0	0	0	0	0	0	0	2132.0	7
300	792	769	228	177	22	12	0	0	0	0	0	0	0	0	0	0	0	0	0	1904.0	5
305	759	829	176	194	24	13	4	1	0	0	0	0	0	0	0	0	0	0	0	1955.0	7
310	781	762	237	181	25	13	1	0	0	0	0	0	0	0	0	0	0	0	0	1950.0	6
315	741	699	411	114	26	8	0	1	0	0	0	0	0	0	0	0	0	0	0	2014.0	7
320	728	821	231	182	30	7	1	0	0	0	0	0	0	0	0	0	0	0	0	1990.0	6
325	757	857	167	180	25	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1901.0	5
330	846	805	144	172	19	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1755.0	5
335	735	837	198	189	27	12	1	1	0	0	0	0	0	0	0	0	0	0	0	1981.0	7
340	926	711	179	159	21	3	1	0	0	0	0	0	0	0	0	0	0	0	0	1651.0	6
345	695	838	222	222	13	8	0	1	0	1	0	0	0	0	0	0	0	0	0	2056.0	9
350	666	851	268	173	30	8	2	2	0	0	0	0	0	0	0	0	0	0	0	2092.0	7
355	957	699	196	129	15	3	1	0	0	0	0	0	0	0	0	0	0	0	0	1559.0	6
360	1814	130	0	54	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	302.0	5

JITTER TEST---EACH DELTA=PRESENT READING-LAST READING.

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TABLE C-12. Synchro-In Jitter Data on True Heading Channel.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

TRUE INPUT ANGLES (FIRST COLUMN) VRS DELTA CONCENTRATION (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading= 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIAION WEIGHTED VALUE AND MAX DELTA ARE LAST TWO COLUMNS

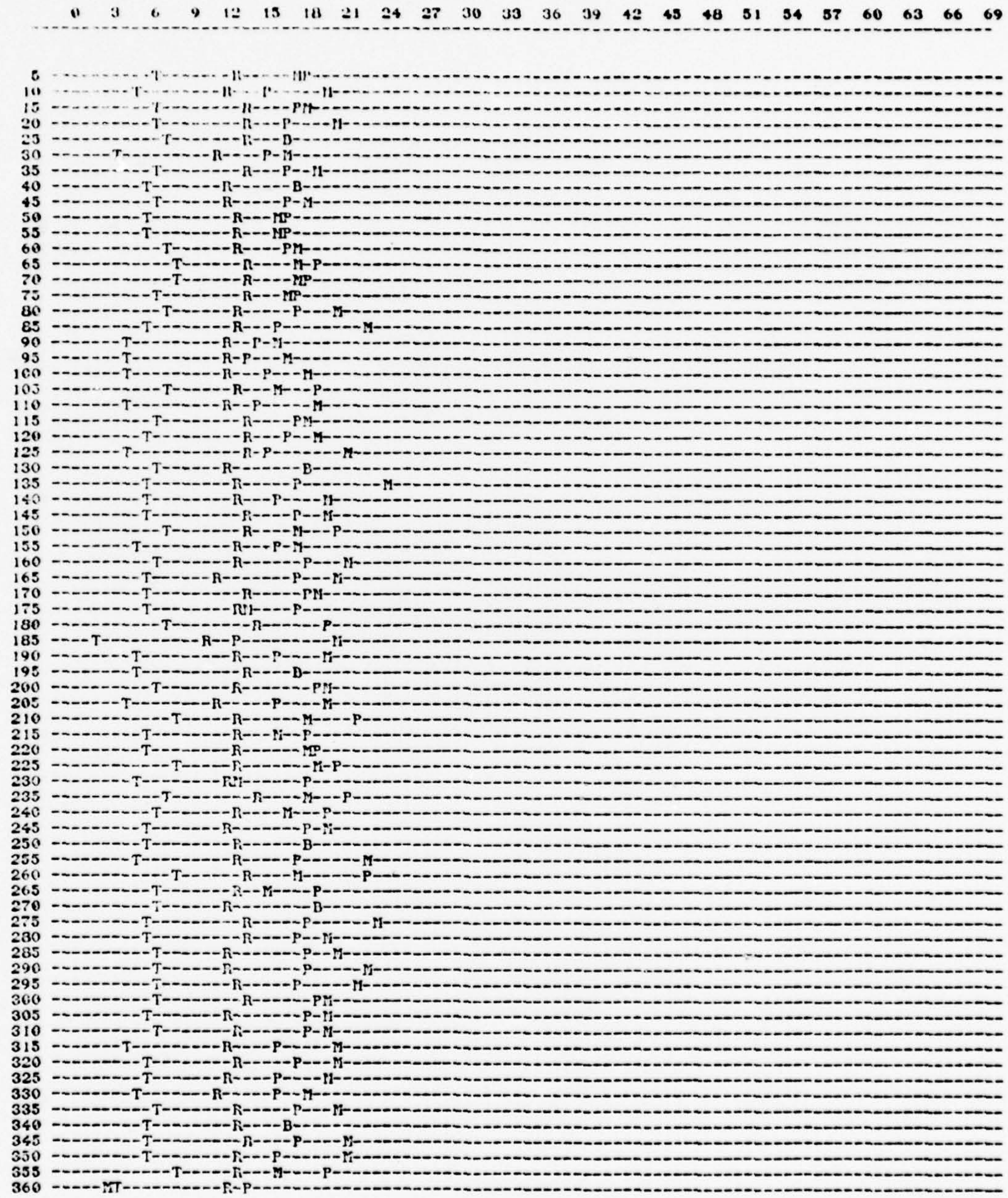
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	WTVL	MXDELT
5	1337	653	0	2	0	5	0	3	0	0	0	0	0	0	0	0	0	0	0	705.0	7
10	1546	434	0	1	0	5	0	14	0	0	0	0	0	0	0	0	0	0	0	560.0	7
15	1378	608	0	1	0	11	0	2	0	0	0	0	0	0	0	0	0	0	0	680.0	7
20	1423	559	0	5	0	4	0	9	0	0	0	0	0	0	0	0	0	0	0	637.0	7
25	1340	643	0	2	0	7	0	8	0	0	0	0	0	0	0	0	0	0	0	740.0	7
30	1636	359	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	390.0	7
35	1394	589	0	3	0	10	0	4	0	0	0	0	0	0	0	0	0	0	0	676.0	7
40	1427	560	0	2	0	7	0	4	0	0	0	0	0	0	0	0	0	0	0	629.0	7
45	1395	583	0	2	0	13	0	7	0	0	0	0	0	0	0	0	0	0	0	703.0	7
50	1454	534	0	1	0	5	0	6	0	0	0	0	0	0	0	0	0	0	0	604.0	7
55	1412	577	0	1	0	3	0	7	0	0	0	0	0	0	0	0	0	0	0	644.0	7
60	1311	672	0	2	0	7	0	8	0	0	0	0	0	0	0	0	0	0	0	769.0	7
65	1257	729	0	3	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	799.0	7
70	1259	724	0	1	0	9	0	7	0	0	0	0	0	0	0	0	0	0	0	821.0	7
75	1345	646	0	3	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	689.0	7
80	1353	621	0	4	0	14	0	8	0	0	0	0	0	0	0	0	0	0	0	759.0	7
85	1411	585	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	611.0	7
90	1546	447	0	0	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	492.0	7
95	1615	376	0	0	0	1	0	8	0	0	0	0	0	0	0	0	0	0	0	437.0	7
100	1552	437	0	2	0	5	0	4	0	0	0	0	0	0	0	0	0	0	0	496.0	7
105	1292	698	0	3	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	746.0	7
110	1552	438	0	3	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	486.0	7
115	1380	610	0	2	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0	660.0	7
120	1412	577	0	0	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	638.0	7
125	1573	423	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	445.0	7
130	1354	630	0	4	0	8	0	4	0	0	0	0	0	0	0	0	0	0	0	710.0	7
135	1430	557	0	2	0	2	0	9	0	0	0	0	0	0	0	0	0	0	0	636.0	7
140	1449	541	0	1	0	5	0	4	0	0	0	0	0	0	0	0	0	0	0	597.0	7
145	1423	565	0	2	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	631.0	7
150	1279	713	0	2	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	753.0	7
155	1532	459	0	1	0	5	0	3	0	0	0	0	0	0	0	0	0	0	0	508.0	7
160	1383	607	0	3	0	6	0	1	0	0	0	0	0	0	0	0	0	0	0	653.0	7
165	1443	549	0	2	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	591.0	7
170	1445	543	0	2	0	7	0	3	0	0	0	0	0	0	0	0	0	0	0	605.0	7
175	1427	563	0	2	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0	613.0	7
180	1297	686	0	5	0	10	0	2	0	0	0	0	0	0	0	0	0	0	0	765.0	7
185	1780	220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	220.0	1
190	1508	487	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	520.0	7
195	1522	469	0	0	0	5	0	4	0	0	0	0	0	0	0	0	0	0	0	522.0	7
200	1365	624	0	1	0	6	0	4	0	0	0	0	0	0	0	0	0	0	0	685.0	7
205	1581	411	0	1	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	453.0	7
210	1189	808	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	825.0	7
215	1423	570	0	2	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	603.0	7
220	1409	578	0	1	0	10	0	2	0	0	0	0	0	0	0	0	0	0	0	645.0	7
225	1246	742	0	1	0	6	0	5	0	0	0	0	0	0	0	0	0	0	0	810.0	7
230	1483	504	0	3	0	7	0	3	0	0	0	0	0	0	0	0	0	0	0	569.0	7
235	1293	690	0	3	0	4	0	10	0	0	0	0	0	0	0	0	0	0	0	789.0	7
240	1364	627	0	1	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	678.0	7
245	1440	553	0	2	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	588.0	7
250	1415	580	0	1	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	609.0	7
255	1456	538	0	1	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	570.0	7
260	1203	784	0	1	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	826.0	7
265	1400	585	0	4	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	658.0	7
270	1375	610	0	4	0	2	0	9	0	0	0	0	0	0	0	0	0	0	0	695.0	7
275	1480	504	0	1	0	6	0	9	0	0	0	0	0	0	0	0	0	0	0	600.0	7
280	1431	555	0	0	0	8	0	6	0	0	0	0	0	0	0	0	0	0	0	637.0	7
285	1394	582	0	4	0	12	0	8	0	0	0	0	0	0	0	0	0	0	0	710.0	7
290	1423	562	0	1	0	4	0	10	0	0	0	0	0	0	0	0	0	0	0	655.0	7
295	1384	605	0	3	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	662.0	7
300	1369	613	0	2	0	9	0	7	0	0	0	0	0	0	0	0	0	0	0	713.0	7
305	1464	520	0	1	0	6	0	9	0	0	0	0	0	0	0	0	0	0	0	616.0	7
310	1418	561	0	2	0	14	0	5	0	0	0	0	0	0	0	0	0	0	0	672.0	7
315	1544	448	0	1	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0	494.0	7
320	1413	573	0	3	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	643.0	7
325	1461	526	0	2	0	8	0	3	0	0	0	0	0	0	0	0	0	0	0	593.0	7
330	1494	494	0	2	0	6	0	4	0	0	0	0	0	0	0	0	0	0	0	558.0	7
335	1396	586	0	4	0	12	0	2	0	0	0	0	0	0	0	0	0	0	0	672.0	7
340	1403	586	0	1	0	4	0	6	0	0	0	0	0	0	0	0	0	0	0	651.0	7
345	1424	557	0	4	0	11	0	4	0	0	0	0	0	0	0	0	0	0	0	652.0	7
350	1477	508	0	1	0	10	0	4	0	0	0	0	0	0	0	0	0	0	0	589.0	7
355	1201	782	0	4	0	9	0	4	0	0	0	0	0	0	0	0	0	0	0	867.0	7
360	1644	352	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	374.0	7

TABLE C-13. Synchro-In Weighted Values of Jitter.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

GRAPH OF WEIGHTED VALUES VRS CHANGE IN ANGLE
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading= 360 DEGREES
True heading= 360Degrees

Y AXIS ACROSS - X AXIS DOWN



WEIGHTED VALUES WERE SCALED BY 100
P = PITCH
R = ROLL
M = MAG HEADING
T = TRUE HEADING
A = PITCH AND ROLL
B = PITCH AND MAG
C = PITCH AND TRUE
D = ROLL AND MAG
E = ROLL AND TRUE
F = PITCH,ROLL,AND MAG
G = PITCH,ROLL,AND TRUE
H = PITCH,MAG,AND TRUE
I = ROLL,MAG,AND TRUE

ACCURACY TEST--EACH DELTA=OPTIMAL READING-PRESENT READING.

TABLE C-14. Synchro-In Pitch Channel Error Excursions.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

PITCH INPUT ANGLES (FIRST COLUMN) VRS ERROR (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE' CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading= 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIATION

	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
5	0	0	0	0	0	0	0	0	0	56	434	389	537	384	0	0	0	0	0
10	0	0	0	0	0	0	0	1	0	91	863	577	257	211	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	69	573	609	449	298	0	0	0	0	0
20	0	0	0	0	0	0	0	1	0	66	616	389	435	293	0	0	0	0	0
25	0	0	0	0	0	0	0	3	0	58	550	581	503	305	0	0	0	0	0
30	0	0	0	0	0	0	0	3	0	140	1003	543	182	129	0	0	0	0	0
35	0	0	0	0	0	0	0	1	0	73	630	577	442	277	0	0	0	0	0
40	0	0	0	0	0	0	0	2	0	52	603	399	431	313	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	58	668	560	411	303	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	63	661	576	424	276	0	0	0	0	0
55	0	0	0	0	0	0	0	3	0	68	603	578	430	318	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	55	509	582	495	339	0	0	0	0	0
65	0	0	0	0	0	0	0	2	0	34	354	397	606	407	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	31	334	614	610	411	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	42	472	605	534	347	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	60	549	616	456	319	0	0	0	0	0
85	0	0	0	0	0	0	0	2	0	56	613	545	452	332	0	0	0	0	0
90	0	0	0	0	0	0	0	1	0	96	867	601	264	171	0	0	0	0	0
95	0	0	0	0	0	0	0	2	0	78	932	576	229	183	0	0	0	0	0
100	0	0	0	0	0	0	0	1	0	96	854	568	267	214	0	0	0	0	0
105	0	0	0	0	0	0	0	1	0	37	457	595	514	396	0	0	0	0	0
110	0	0	0	0	0	0	0	3	0	77	862	611	265	182	0	0	0	0	0
115	0	0	0	0	0	0	0	1	0	53	531	629	443	343	0	0	0	0	0
120	0	0	0	0	0	0	0	1	0	72	635	592	395	305	0	0	0	0	0
125	0	0	0	0	0	0	0	2	0	111	847	609	236	175	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	58	450	597	485	410	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	70	571	609	396	354	0	0	0	0	0
140	0	0	0	0	0	0	0	2	0	86	730	545	368	269	0	0	0	0	0
145	0	0	0	0	0	0	0	1	0	67	624	631	366	311	0	0	0	0	0
150	0	0	0	0	0	0	0	1	0	26	286	638	510	539	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	67	771	660	251	251	0	0	0	0	0
160	0	0	0	0	0	0	0	1	0	61	497	633	430	378	0	0	0	0	0
165	0	0	0	0	0	0	0	1	0	83	610	640	312	354	0	0	0	0	0
170	0	0	0	0	0	0	0	1	0	52	555	643	363	386	0	0	0	0	0
175	0	0	0	0	0	0	0	1	0	67	552	632	376	372	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	46	353	642	453	506	0	0	0	0	0
185	0	0	0	0	0	0	0	1	0	138	1211	630	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	88	743	641	250	276	0	0	0	0	0
195	0	0	0	0	0	0	0	1	0	80	680	640	268	331	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	60	490	653	377	420	0	0	0	0	0
205	0	0	0	0	0	0	0	1	0	99	771	638	240	231	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	15	195	692	502	596	0	0	0	0	0
215	0	0	0	0	0	0	0	0	0	69	551	645	360	375	0	0	0	0	0
220	0	0	0	0	0	0	0	1	0	80	500	666	378	375	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	33	240	621	547	559	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	82	645	640	293	340	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	35	302	613	475	575	0	0	0	0	0
240	0	0	0	0	0	0	0	1	0	60	483	619	402	435	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	64	603	620	360	348	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	75	510	614	395	406	0	0	0	0	0
255	0	0	0	0	0	0	0	0	0	72	593	588	358	389	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	21	149	626	563	641	0	0	0	0	0
265	0	0	0	0	0	0	0	0	0	55	462	662	411	410	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	53	533	650	376	388	0	0	0	0	0
275	0	0	0	0	0	0	0	1	0	65	613	649	324	348	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	74	599	616	356	355	0	0	0	0	0
285	0	0	0	0	0	0	0	0	0	66	565	629	376	364	0	0	0	0	0
290	0	0	0	0	0	0	0	2	0	59	602	666	337	334	0	0	0	0	0
295	0	0	0	0	0	0	0	1	0	59	555	628	412	345	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	43	422	637	471	427	0	0	0	0	0
305	0	0	0	0	0	0	0	0	0	86	638	631	336	309	0	0	0	0	0
310	0	0	0	0	0	0	0	1	0	72	588	624	374	341	0	0	0	0	0
315	0	0	0	0	0	0	0	2	0	73	746	627	303	249	0	0	0	0	0
320	0	0	0	0	0	0	0	1	0	78	514	613	410	384	0	0	0	0	0
325	0	0	0	0	0	0	0	1	0	83	714	597	347	258	0	0	0	0	0
330	0	0	0	0	0	0	0	0	0	89	743	602	331	235	0	0	0	0	0
335	0	0	0	0	0	0	0	0	0	69	594	620	404	313	0	0	0	0	0
340	0	0	0	0	0	0	0	2	0	61	571	614	431	321	0	0	0	0	0
345	0	0	0	0	0	0	0	2	0	58	583	572	458	327	0	0	0	0	0
350	0	0	0	0	0	0	0	1	0	87	765	573	336	238	0	0	0	0	0
355	0	0	0	0	0	0	0	2	0	34	303	638	572	451	0	0	0	0	0
360	0	0	0	0	0	0	0	1	0	110	1075	545	154	115	0	0	0	0	0

ACCURACY TEST--EACH DELTA=OPTIMAL READING-PRESENT READING.

TABLE C-15. Synhro-In Roll Channel Error Excursions.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JB3003
TEST OF MAG HEADING.

ROLL INPUT ANGLES (FIRST COLUMN) VRS ERROR (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE' CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading= 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIATION

	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
5	0	0	0	0	0	0	0	16	0	51	512	621	729	71	0	0	0	0	0
10	0	0	0	0	0	0	0	16	0	119	1015	469	341	40	0	0	0	0	0
15	0	0	0	0	0	0	0	18	0	62	633	535	592	85	0	0	0	0	0
20	0	0	0	0	0	0	0	18	0	86	715	563	541	77	0	0	0	0	0
25	0	0	0	0	0	0	0	23	0	60	637	605	605	70	0	0	0	0	0
30	0	0	0	0	0	0	0	32	0	95	1225	374	240	34	0	0	0	0	0
35	0	0	0	0	0	0	0	25	0	97	708	531	589	59	0	0	0	0	0
40	0	0	0	0	0	0	0	19	0	63	694	587	582	55	0	0	0	0	0
45	0	0	0	0	0	0	0	14	0	74	736	562	551	63	0	0	0	0	0
50	0	0	0	0	0	0	0	24	0	63	774	544	527	68	0	0	0	0	0
55	0	0	0	0	0	0	0	27	0	69	692	570	591	51	0	0	0	0	0
60	0	0	0	0	0	0	0	16	0	67	606	607	627	77	0	0	0	0	0
65	0	0	0	0	0	0	0	11	0	38	389	685	772	105	0	0	0	0	0
70	0	0	0	0	0	0	0	15	0	40	408	693	759	83	0	0	0	0	0
75	0	0	0	0	0	0	0	15	0	39	547	623	663	113	0	0	0	0	0
80	0	0	0	0	0	0	0	14	0	52	650	614	588	82	0	0	0	0	0
85	0	0	0	0	0	0	0	15	0	64	671	628	553	69	0	0	0	0	0
90	0	0	0	0	0	0	0	23	0	100	1029	460	352	36	0	0	0	0	0
95	0	0	0	0	0	0	0	21	0	99	1081	439	317	43	0	0	0	0	0
100	0	0	0	0	0	0	0	19	0	101	991	500	348	41	0	0	0	0	0
105	0	0	0	0	0	0	0	16	0	56	521	637	685	85	0	0	0	0	0
110	0	0	0	0	0	0	0	29	0	112	1039	426	354	40	0	0	0	0	0
115	0	0	0	0	0	0	0	19	0	70	625	615	601	70	0	0	0	0	0
120	0	0	0	0	0	0	0	27	0	74	765	533	533	68	0	0	0	0	0
125	0	0	0	0	0	0	0	31	0	90	1026	473	331	49	0	0	0	0	0
130	0	0	0	0	0	0	0	13	0	57	552	618	677	83	0	0	0	0	0
135	0	0	0	0	0	0	0	14	0	75	691	572	580	68	0	0	0	0	0
140	0	0	0	0	0	0	0	24	0	100	872	503	439	62	0	0	0	0	0
145	0	0	0	0	0	0	0	16	0	92	755	542	504	91	0	0	0	0	0
150	0	0	0	0	0	0	0	12	0	29	378	675	791	115	0	0	0	0	0
155	0	0	0	0	0	0	0	23	0	95	930	445	431	76	0	0	0	0	0
160	0	0	0	0	0	0	0	13	0	57	626	562	648	94	0	0	0	0	0
165	0	0	0	0	0	0	0	11	0	79	778	540	522	70	0	0	0	0	0
170	0	0	0	0	0	0	0	22	0	67	671	580	571	89	0	0	0	0	0
175	0	0	0	0	0	0	0	16	0	66	695	563	585	75	0	0	0	0	0
180	0	0	0	0	0	0	0	8	0	62	421	680	721	108	0	0	0	0	0
185	0	0	0	0	0	0	0	21	0	155	1515	309	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	16	0	102	918	488	416	60	0	0	0	0	0
195	0	0	0	0	0	0	0	19	0	77	851	519	451	83	0	0	0	0	0
200	0	0	0	0	0	0	0	10	0	61	634	568	621	106	0	0	0	0	0
205	0	0	0	0	0	0	0	16	0	83	995	466	394	46	0	0	0	0	0
210	0	0	0	0	0	0	0	5	0	17	249	732	870	127	0	0	0	0	0
215	0	0	0	0	0	0	0	12	0	63	706	571	565	83	0	0	0	0	0
220	0	0	0	0	0	0	0	11	0	61	664	601	573	90	0	0	0	0	0
225	0	0	0	0	0	0	0	3	0	22	310	690	841	134	0	0	0	0	0
230	0	0	0	0	0	0	0	12	0	65	858	505	477	83	0	0	0	0	0
235	0	0	0	0	0	0	0	8	0	41	369	696	771	115	0	0	0	0	0
240	0	0	0	0	0	0	0	6	0	55	609	585	635	110	0	0	0	0	0
245	0	0	0	0	0	0	0	15	0	74	752	530	547	82	0	0	0	0	0
250	0	0	0	0	0	0	0	7	0	57	650	564	626	96	0	0	0	0	0
255	0	0	0	0	0	0	0	10	0	66	693	556	578	97	0	0	0	0	0
260	0	0	0	0	0	0	0	5	0	27	180	675	950	163	0	0	0	0	0
265	0	0	0	0	0	0	0	16	0	58	590	604	644	88	0	0	0	0	0
270	0	0	0	0	0	0	0	6	0	65	671	604	578	76	0	0	0	0	0
275	0	0	0	0	0	0	0	15	0	82	753	571	498	81	0	0	0	0	0
280	0	0	0	0	0	0	0	17	0	82	721	540	568	72	0	0	0	0	0
285	0	0	0	0	0	0	0	9	0	60	683	573	597	78	0	0	0	0	0
290	0	0	0	0	0	0	0	15	0	62	778	546	531	68	0	0	0	0	0
295	0	0	0	0	0	0	0	12	0	73	693	563	573	84	0	0	0	0	0
300	0	0	0	0	0	0	0	13	0	37	548	600	696	106	0	0	0	0	0
305	0	0	0	0	0	0	0	11	0	69	829	525	501	65	0	0	0	0	0
310	0	0	0	0	0	0	0	19	0	60	744	556	554	67	0	0	0	0	0
315	0	0	0	0	0	0	0	22	0	85	913	521	414	45	0	0	0	0	0
320	0	0	0	0	0	0	0	10	0	57	615	595	643	80	0	0	0	0	0
325	0	0	0	0	0	0	0	17	0	95	859	502	462	65	0	0	0	0	0
330	0	0	0	0	0	0	0	13	0	86	914	464	465	58	0	0	0	0	0
335	0	0	0	0	0	0	0	18	0	72	729	578	533	70	0	0	0	0	0
340	0	0	0	0	0	0	0	18	0	72	680	586	572	72	0	0	0	0	0
345	0	0	0	0	0	0	0	28	0	67	686	576	558	83	0	0	0	0	0
350	0	0	0	0	0	0	0	21	0	122	884	447	471	55	0	0	0	0	0
355	0	0	0	0	0	0	0	13	0	35	369	686	813	84	0	0	0	0	0
360	0	0	0	0	0	0	0	29	0	126	1223	388	204	30	0	0	0	0	0

ACCURACY TEST--EACH DELTA=OPTIMAL READING-PRESENT READING.

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TABLE C-16. Synchro-In Magnetic Heading Error Excursions.

```
DATE = 1-JUL-77                    FILE:SR0701.MAC TC2A:JBB003
TEST OF MAG HEADING.

         MAG      INPUT ANGLES (FIRST COLUMN) VRS ERROR (NEXT 19 COLUMNS)
                            MAG      WAS THE VARIABLE' CHANNEL
                        INITIALLY Pitch        = 360 DEGREES
                                  Roll         = 360 DEGREES
                                  Mag heading  = 360 DEGREES
                                  True heading = 360 Degrees
```

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIATION

	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
5	0	0	0	0	0	40	685	569	455	250	1	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	21	439	837	437	246	0	0	0	0	0	0	0	0
15	0	0	0	0	1	103	732	821	289	54	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	12	592	579	747	70	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	142	736	841	281	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	5	322	988	657	28	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	225	843	831	101	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	64	730	1093	113	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	105	1593	288	14	0	0	0	0	0	0	0	0	0
50	0	0	0	0	1	264	1196	529	10	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	172	1027	757	44	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	2	306	1037	629	26	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	2	250	854	855	39	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	22	322	711	929	16	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	126	569	1052	252	1	0	0	0	0	0	0	0	0
80	0	0	0	0	53	674	503	647	123	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	239	551	600	446	164	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	394	842	0	718	0	46	0	0	0	0	0	0	0
95	0	0	0	0	0	0	12	746	554	375	283	30	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	3	520	668	563	199	47	0	0	0	0	0	0
105	0	0	0	0	0	0	26	314	433	502	707	18	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	58	446	799	408	213	76	0	0	0	0	0	0
115	0	0	0	0	0	0	0	60	464	391	520	484	81	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	27	382	553	534	421	83	0	0	0	0	0
125	0	0	0	0	0	0	0	5	363	682	490	388	72	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	38	274	415	874	374	25	0	0	0	0	0
135	0	0	0	0	0	0	0	0	10	343	428	677	528	12	0	0	0	0	0
140	0	0	0	0	0	0	0	19	191	694	614	338	143	1	0	0	0	0	0
145	0	0	0	0	0	0	0	2	144	390	534	586	339	5	0	0	0	0	0
150	0	0	0	0	0	0	0	17	178	364	761	658	22	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	98	507	595	559	213	28	0	0	0	0	0
160	0	0	0	0	0	0	0	38	270	444	578	486	183	1	0	0	0	0	0
165	0	0	0	0	0	0	0	3	390	371	492	453	291	0	0	0	0	0	0
170	0	0	0	0	0	0	72	645	307	497	450	29	0	0	0	0	0	0	0
175	0	0	0	0	0	0	1	227	656	751	306	59	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	595	0	20	884	501	0	0	0	0	0	0	0
185	0	0	0	0	0	0	81	1232	480	207	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	3	238	686	530	428	115	0	0	0	0	0	0	0
195	0	0	0	0	0	53	391	1000	429	127	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	12	370	595	907	116	0	0	0	0	0	0	0	0	0
205	0	0	0	0	1	200	812	657	318	12	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	75	1010	658	257	0	0	0	0	0	0	0	0	0
215	0	0	0	0	0	221	987	676	116	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	47	520	1129	304	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	11	227	965	797	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	120	452	1322	106	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	1	473	894	609	23	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	77	1043	782	98	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	286	807	719	188	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	2	343	950	620	85	0	0	0	0	0	0	0	0	0	0
255	0	0	0	0	0	264	517	788	425	6	0	0	0	0	0	0	0	0	0
260	0	0	0	0	514	870	523	91	2	0	0	0	0	0	0	0	0	0	0
265	0	0	0	0	7	216	972	605	190	10	0	0	0	0	0	0	0	0	0
270	0	0	0	0	503	91	1331	55	20	0	0	0	0	0	0	0	0	0	0
275	0	0	0	0	0	2	323	357	698	593	27	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	7	253	616	507	450	167	0	0	0	0	0	0	0
285	0	0	0	0	0	33	425	576	395	444	127	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	122	363	547	483	308	97	0	0	0	0	0	0	0
295	0	0	0	0	0	2	200	647	413	401	330	7	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	91	554	660	355	325	15	0	0	0	0	0	0
305	0	0	0	0	0	0	11	297	511	343	611	227	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	24	419	400	547	492	118	0	0	0	0	0	0
315	0	0	0	0	0	0	36	113	341	953	544	13	0	0	0	0	0	0	0
320	0	0	0	0	0	0	21	325	549	502	476	127	0	0	0	0	0	0	0
325	0	0	0	0	0	0	0	47	345	590	485	511	22	0	0	0	0	0	0
330	0	0	0	0	0	0	56	372	398	595	487	92	0	0	0	0	0	0	0
335	0	0	0	0	0	0	1	200	453	462	528	321	35	0	0	0	0	0	0
340	0	0	0	0	0	0	19	282	664	489	414	132	0	0	0	0	0	0	0
345	0	0	0	0	0	0	0	93	704	402	400	381	18	0	0	0	0	0	0
350	0	0	0	0	0	28	306	328	592	698	48	0	0	0	0	0	0	0	0
355	0	0	0	0	0	0	114	1000	433	265	186	2	0	0	0	0	0	0	0
360	0	0	0	0	0	0	67	315	30	0	1534	4	0	0	0	0	0	0	0

ACCURACY TEST--EACH DELTA=OPTIMAL READING-PRESENT READING.

TABLE C-17. Synchro-In True Heading Error Excursions.

DATE = 1-JUL-77 FILE:SR0701.MAG TC2A:JBB003
TEST OF MAG HEADING.

TRUE INPUT ANGLES (FIRST COLUMN) VRS ERROR (NEXT 19 COLUMNS)
MAG WAS THE VARIABLE' CHANNEL
INITIALLY Pitch = 360 DEGREES
Roll = 360 DEGREES
Mag heading = 360 DEGREES
True heading = 360 Degrees

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIATION

	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16	18
5	0	0	0	0	0	0	844	503	0	32	521	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	427	248	0	67	1258	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	681	437	0	32	830	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	704	349	0	56	891	0	0	0	0	0	0	0	0
25	0	0	0	0	0	1	756	417	0	51	775	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	289	162	0	75	1474	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	660	389	0	52	899	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	718	379	0	49	834	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	640	397	0	47	916	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	664	346	0	38	952	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	709	391	0	37	863	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	720	495	0	38	747	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	955	533	0	26	486	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	916	558	0	28	498	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	801	494	0	33	672	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	751	408	0	48	793	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	704	398	0	39	839	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	416	252	0	62	1270	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	378	216	0	80	1326	0	0	0	0	0	0	0	0
100	0	0	0	0	0	1	439	224	0	61	1253	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	846	458	0	34	662	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	402	245	0	72	1281	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	742	413	0	41	804	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	618	370	0	55	957	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	401	226	0	68	1305	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	835	436	0	41	688	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	733	352	0	43	872	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	559	302	0	65	1074	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	633	348	0	55	964	0	0	0	0	0	0	0	0
150	0	0	0	0	0	1	1020	495	0	20	464	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	501	272	0	72	1155	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	789	401	0	43	767	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	666	321	0	58	955	0	0	0	0	0	0	0	0
170	0	0	0	0	0	1	764	321	0	58	856	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	730	346	0	50	874	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	932	459	0	46	563	0	0	0	0	0	0	0	0
185	0	0	0	0	0	0	0	0	0	119	1381	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	524	249	0	79	1143	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	565	280	0	53	1102	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	781	376	0	64	779	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	475	207	0	77	1240	1	0	0	0	0	0	0	0
210	0	0	0	0	0	0	1143	536	0	17	304	0	0	0	0	0	0	0	0
215	0	0	0	0	0	0	717	361	0	53	869	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	764	355	0	52	829	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	1086	496	0	25	393	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	633	271	0	76	1020	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	1014	488	0	30	467	1	0	0	0	0	0	0	0
240	0	0	0	0	0	0	823	387	0	59	730	1	0	0	0	0	0	0	0
245	0	0	0	0	0	0	668	347	0	56	929	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	801	354	0	42	803	0	0	0	0	0	0	0	0
255	0	0	0	0	0	0	746	320	0	54	880	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	1205	549	0	19	227	0	0	0	0	0	0	0	0
265	0	0	0	0	0	0	810	402	0	45	743	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	723	393	0	58	826	0	0	0	0	0	0	0	0
275	0	0	0	0	0	0	679	303	0	47	971	0	0	0	0	0	0	0	0
280	0	0	0	0	0	1	692	327	0	57	923	0	0	0	0	0	0	0	0
285	0	0	0	0	0	0	735	363	0	62	840	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	655	338	0	62	945	0	0	0	0	0	0	0	0
295	0	0	0	0	0	0	708	382	0	53	837	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	878	422	0	38	662	0	0	0	0	0	0	0	0
305	0	0	0	0	0	0	648	305	0	50	996	1	0	0	0	0	0	0	0
310	0	0	0	0	0	0	677	358	0	58	907	0	0	0	0	0	0	0	0
315	0	0	0	0	0	0	525	274	0	54	1147	0	0	0	0	0	0	0	0
320	0	0	0	0	0	0	778	387	0	38	797	0	0	0	0	0	0	0	0
325	0	0	0	0	0	0	578	290	0	67	1065	0	0	0	0	0	0	0	0
330	0	0	0	0	0	0	539	289	0	62	1110	0	0	0	0	0	0	0	0
335	0	0	0	0	0	0	676	370	0	56	898	0	0	0	0	0	0	0	0
340	0	0	0	0	0	0	703	387	0	49	861	0	0	0	0	0	0	0	0
345	0	0	0	0	0	0	757	344	0	40	859	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	523	303	0	62	1112	0	0	0	0	0	0	0	0
355	0	0	0	0	0	1	930	593	0	27	449	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	252	132	0	89	1527	0	0	0	0	0	0	0	0

DIGITAL-SYNCRO-DIGITAL TEST

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TABLE C-18. Typical Data for Standard TC-2.

DATE = 25-JUL-75 4:30 PM FILE PITCO7.251 TC2 SER CVV8
ABSOLUTE COMPARE CHANGED TO THEORETIC ANGLE COMPARE

CHANNEL 1 INPUT ANGLES (FIRST COLUMN) VRS DELTA CONCENTRATION (NEXT 19 COLUMNS)
CHANNEL 1 WAS THE VARIABLE CHANNEL
INITIALLY CHANNEL ONE = 180 DEGREES 5 OCTAL
CHANNEL TWO = 180 DEGREES 5 OCTAL
CHANNEL THREE = 180 DEGREES 100002 OCTAL

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIATION WEIGHTED VALUE AND MAX DELT ARE LAST TWO COLUMNS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	WTVL	MXDELT
5	1155	529	93	132	26	61	1	3	0	0	0	0	0	0	0	0	0	0	0	1547.0	7
10	1045	589	150	129	43	42	2	0	0	0	0	0	0	0	0	0	0	0	0	1670.0	6
15	1211	645	96	44	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	985.0	4
20	989	758	130	104	16	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1409.0	5
25	1136	661	132	59	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1152.0	5
30	1031	782	93	39	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1255.0	4
35	1120	691	114	63	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1159.0	5
40	1012	836	113	38	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1181.0	5
45	1225	736	30	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	823.0	3
50	1224	698	62	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	871.0	4
55	1160	723	94	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	981.0	4
60	1260	613	87	38	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	909.0	4
65	1079	746	114	55	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1163.0	4
70	1084	718	114	76	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1208.0	5
75	1068	761	94	74	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1184.0	5
80	1001	773	105	101	16	3	1	0	0	0	0	0	0	0	0	0	0	0	0	1371.0	6
85	1168	524	103	116	34	49	4	2	0	0	0	0	0	0	0	0	0	0	0	1497.0	7
90	1030	681	0	142	0	87	0	47	0	13	0	0	0	0	0	0	0	0	0	1988.0	9
95	1221	538	33	47	38	73	36	12	1	1	0	0	0	0	0	0	0	0	0	1579.0	9
100	1115	589	101	89	36	54	12	4	0	0	0	0	0	0	0	0	0	0	0	1572.0	7
105	1088	638	53	102	36	64	14	4	1	0	0	0	0	0	0	0	0	0	0	1634.0	8
110	1170	573	50	50	30	83	21	23	0	0	0	0	0	0	0	0	0	0	0	1645.0	7
115	986	685	79	66	25	84	35	32	5	3	0	0	0	0	0	0	0	0	0	2062.0	9
120	1110	615	50	55	32	77	30	27	4	0	0	0	0	0	0	0	0	0	0	1794.0	8
125	947	768	70	41	21	77	33	37	4	2	0	0	0	0	0	0	0	0	0	2007.0	9
130	1139	595	52	61	32	81	23	17	0	0	0	0	0	0	0	0	0	0	0	1672.0	7
135	775	896	136	41	83	56	0	13	0	0	0	0	0	0	0	0	0	0	0	1994.0	7
140	993	739	67	32	43	82	19	22	3	0	0	0	0	0	0	0	0	0	0	1843.0	8
145	1106	603	74	57	21	70	32	31	6	0	0	0	0	0	0	0	0	0	0	1813.0	8
150	1148	594	69	42	32	82	22	8	3	0	0	0	0	0	0	0	0	0	0	1608.0	8
155	978	697	91	69	26	53	36	40	6	4	0	0	0	0	0	0	0	0	0	2035.0	9
160	1074	632	77	66	45	86	10	10	0	0	0	0	0	0	0	0	0	0	0	1724.0	7
165	1170	561	75	107	41	33	7	5	1	0	0	0	0	0	0	0	0	0	0	1446.0	8
170	1155	516	123	96	50	45	8	6	0	1	0	0	0	0	0	0	0	0	0	1574.0	9
175	1179	537	50	69	41	89	21	12	2	0	0	0	0	0	0	0	0	0	0	1679.0	8
180	1137	496	0	185	112	8	52	2	7	1	0	0	0	0	0	0	0	0	0	1930.0	9
185	1203	379	91	230	57	37	2	1	0	0	0	0	0	0	0	0	0	0	0	1683.0	7
190	1077	657	76	100	44	37	6	3	0	0	0	0	0	0	0	0	0	0	0	1527.0	7
195	1108	662	112	97	14	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1268.0	5
200	988	761	110	103	24	13	1	0	0	0	0	0	0	0	0	0	0	0	0	1457.0	6
205	1256	542	98	88	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1070.0	5
210	1081	759	93	62	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1152.0	5
215	1024	791	130	49	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1222.0	4
220	1173	714	77	34	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	978.0	4
225	882	971	136	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1276.0	3
230	1287	644	47	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	804.0	3
235	1170	719	79	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	973.0	3
240	1019	805	98	73	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1241.0	5
245	1331	524	91	51	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	874.0	5
250	1009	714	139	110	23	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1439.0	5
255	1269	591	87	49	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	929.0	5
260	1261	496	71	112	37	19	1	3	0	0	0	0	0	0	0	0	0	0	0	1244.0	7
265	1102	701	68	78	22	19	8	2	0	0	0	0	0	0	0	0	0	0	0	1316.0	7
270	932	314	401	213	0	120	0	11	0	9	0	0	0	0	0	0	0	0	0	2513.0	9
275	1055	640	82	113	24	62	17	6	1	0	0	0	0	0	0	0	0	0	0	1701.0	8
280	1102	657	68	46	17	51	28	28	2	1	0	0	0	0	0	0	0	0	0	1643.0	9
285	1128	654	55	82	37	37	5	2	0	0	0	0	0	0	0	0	0	0	0	1387.0	7
290	1099	655	63	39	19	65	29	22	5	4	0	0	0	0	0	0	0	0	0	1703.0	9
295	1051	651	95	36	28	84	29	22	4	0	0	0	0	0	0	0	0	0	0	1841.0	8
300	1148	591	67	27	15	71	40	37	4	0	0	0	0	0	0	0	0	0	0	1752.0	8
305	1112	640	77	28	12	54	38	35	3	1	0	0	0	0	0	0	0	0	0	1702.0	9
310	1103	666	65	58	38	54	14	2	0	0	0	0	0	0	0	0	0	0	0	1490.0	7
315	859	890	89	39	25	53	7	38	0	0	0	0	0	0	0	0	0	0	0	1858.0	7
320	1049	658	113	72	55	38	13	2	0	0	0	0	0	0	0	0	0	0	0	1602.0	7
325	1164	593	73	35	13	73	27	16	5	1	0	0	0	0	0	0	0	0	0	1584.0	9
330	1130	645	50	27	19	72	25	24	7	1	0	0	0	0	0	0	0	0	0	1645.0	9
335	1174	566	77	67	45	50	9	12	0	0	0	0	0	0	0	0	0	0	0	1489.0	7
340	1101	629	98	58	23	45	21	22	3	0	0	0	0	0	0	0	0	0	0	1620.0	8
345	1273	514	56	76	37	40	4	0	0	0	0	0	0	0	0	0	0	0	0	1226.0	6
350	1273	522	41	33	24	76	22	9	0	0	0	0	0	0	0	0	0	0	0	1374.0	7
355	1110	458	177	132	75	38	8	2	0	0	0	0	0	0	0	0	0	0	0	1760.0	7
360	962	761	0	153	26	68	27	2	1	0	0	0	0	0	0	0	0	0	0	1848.0	8

TABLE C-19. Typical Data for Preproduction TC-2A.

DATE = 21-JUL-75 5:30 PM FILE PITC07.211 TC2A SER GXA0004 SHLD
ABSOLUTE COMPARE CHANGED TO THEORETIC ANGLE COMPARE

CHANNEL 1 INPUT ANGLES (FIRST COLUMN) VRS DELTA CONCENTRATION (NEXT 17 COLUMNS)
CHANNEL 1 WAS THE VARIABLE CHANNEL
INITIALLY CHANNEL ONE = 360 DEGREES
CHANNEL TWO = 360 DEGREES
CHANNEL THREE = 360 DEGREES

EACH DELTA EQUALS ONE HALF OF A MIN. DEVIATION WEIGHTED VALUE AND MAX DELT ARE LAST TWO COLUMNS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	WTVL	MXDELT
5	1006	678	145	143	14	5	0	0	0	4	0	2	3	0	0	0	0	0	0	1572.0	12
10	843	691	199	202	26	28	3	2	0	0	3	1	1	1	0	0	0	0	0	2037.0	13
15	697	697	259	244	60	35	3	3	0	1	0	0	0	1	0	0	0	0	0	2423.0	13
20	768	626	252	267	49	34	3	0	1	0	0	0	0	0	0	0	0	0	0	2323.0	8
25	614	715	255	274	58	60	16	5	0	2	0	1	0	0	0	0	0	0	0	2739.0	11
30	618	694	182	346	58	74	10	13	1	4	0	0	0	0	0	0	0	0	0	2893.0	9
35	597	658	201	323	96	39	17	13	3	3	0	0	0	0	0	0	0	0	0	3102.0	9
40	544	662	250	336	80	102	11	14	0	1	0	0	0	0	0	0	0	0	0	3173.0	9
45	407	570	450	328	23	151	45	17	0	6	0	1	1	0	0	0	0	0	0	3785.0	18
50	563	675	221	338	94	91	14	4	0	0	0	0	0	0	0	0	0	0	0	3074.0	7
55	555	696	236	314	95	79	16	9	0	0	0	0	0	0	0	0	0	0	0	3044.0	7
60	587	652	266	299	81	71	20	17	4	3	0	0	0	0	0	0	0	0	0	3058.0	9
65	608	689	219	335	64	62	8	9	4	1	0	1	0	0	0	0	0	0	0	2861.0	11
70	649	705	245	282	75	37	5	2	0	0	0	0	0	0	0	0	0	0	0	2570.0	7
75	624	656	271	319	72	51	0	5	0	2	0	0	0	0	0	0	0	0	0	2751.0	9
80	672	663	253	309	52	40	1	1	0	3	1	1	1	2	1	0	0	0	0	2617.0	14
85	795	621	244	274	46	12	2	0	1	2	0	2	0	1	0	0	0	0	0	2248.0	13
90	980	285	246	199	0	2	0	56	11	178	0	32	0	0	0	0	0	1	0	3905.0	17
95	1038	690	150	95	17	5	0	0	0	0	0	1	0	0	2	1	1	0	0	1438.0	16
100	838	733	214	168	30	11	0	0	0	0	1	0	0	3	0	2	0	0	0	1919.0	15
105	752	735	215	222	33	29	6	1	0	0	0	0	0	0	2	2	3	0	0	2257.0	16
110	709	694	252	263	49	22	6	2	0	0	0	0	0	0	0	1	0	0	2	2394.0	18
115	631	697	237	272	69	71	10	6	0	0	0	0	0	0	0	1	1	2	3	2839.0	18
120	610	683	226	309	74	65	15	11	2	0	0	0	0	0	0	0	0	1	4	2955.0	18
125	567	724	212	310	83	78	12	6	0	1	0	0	0	0	0	1	0	0	6	3046.0	18
130	559	693	190	318	90	98	26	15	2	3	0	1	0	0	0	0	1	0	4	3280.0	18
135	431	692	334	334	40	98	34	23	4	5	0	0	0	0	0	1	0	0	4	3541.0	18
140	591	630	251	328	80	74	14	13	8	6	4	0	0	0	0	0	0	0	1	3157.0	18
145	595	654	275	310	72	71	14	5	0	1	0	0	0	0	0	1	0	1	1	2955.0	18
150	592	674	235	291	92	69	25	13	0	2	2	0	0	0	0	0	0	0	5	3099.0	18
153	592	631	287	311	77	62	8	4	1	0	0	0	0	0	0	0	0	0	5	2984.0	18
160	675	649	260	300	49	52	4	2	0	0	0	0	0	0	1	2	1	0	5	2713.0	18
165	644	699	214	313	69	54	2	1	0	0	0	0	0	0	0	1	0	2	1	2698.0	18
170	762	753	210	209	38	21	0	0	0	0	0	0	1	1	2	1	1	1	0	2158.0	17
175	1047	617	152	142	21	9	0	0	0	0	0	0	1	4	1	5	1	0	0	1645.0	16
180	1181	720	6	85	0	2	0	0	0	0	0	0	0	3	0	3	0	0	0	1081.0	15
185	999	698	154	126	11	4	0	2	0	1	1	3	1	0	0	0	0	0	0	1526.0	12
190	748	795	211	202	29	11	0	0	0	0	0	0	0	1	0	0	0	0	0	2022.0	13
195	667	748	242	242	54	33	4	2	1	3	1	2	0	1	0	0	0	0	0	2457.0	13
200	694	696	265	245	50	44	1	3	1	3	1	0	0	0	0	0	0	0	0	2426.0	10
205	674	723	232	256	65	32	6	8	0	3	0	1	0	0	0	0	0	0	0	2505.0	11
210	596	675	225	349	71	63	15	4	0	1	1	0	0	0	0	0	0	0	0	2908.0	10
215	625	697	236	292	77	54	6	13	0	0	0	0	0	0	0	0	0	0	0	2750.0	7
220	676	677	264	251	58	49	15	8	2	0	0	0	0	0	0	0	0	0	0	2597.0	8
225	406	646	392	306	98	97	40	12	0	2	0	0	0	1	0	0	0	0	0	3580.0	13
230	631	686	243	303	66	50	11	10	0	0	0	0	0	0	0	0	0	0	0	2731.0	7
235	622	687	232	305	73	62	13	6	0	0	0	0	0	0	0	0	0	0	0	2788.0	7
240	591	702	230	298	80	76	15	5	0	3	0	0	0	0	0	0	0	0	0	2908.0	9
245	644	698	231	277	75	63	3	5	3	1	0	0	0	0	0	0	0	0	0	2692.0	9
250	579	702	253	339	66	51	7	1	0	1	0	1	0	0	0	0	0	0	0	2813.0	11
255	585	746	249	310	80	28	1	0	1	0	0	0	0	0	0	0	0	0	0	2648.0	8
260	705	713	278	246	35	21	0	0	0	0	0	2	0	0	0	0	0	0	0	2274.0	11
265	782	724	231	213	35	9	1	1	1	2	0	1	0	0	0	0	0	0	0	2060.0	11
270	1240	182	150	121	0	67	90	144	0	6	0	0	0	0	0	0	0	0	0	2782.0	9
275	957	745	167	114	12	1	0	1	0	0	0	0	1	2	0	0	0	0	0	1519.0	13
280	775	815	209	161	23	10	0	0	0	0	0	0	0	1	0	2	1	2	1	1969.0	18
285	779	705	216	220	48	23	1	2	0	0	0	0	0	0	0	4	0	0	2	2220.0	18
290	688	752	224	256	45	19	6	1	0	0	0	0	0	0	1	2	2	4	0	2430.0	17
295	616	755	232	256	51	60	11	5	0	0	0	0	0	0	2	3	2	3	4	2820.0	18
300	665	681	219	274	77	59	11	7	0	1	0	0	0	0	0	2	0	0	4	2770.0	18
305	661	689	188	306	36	74	9	7	2	2	0	0	0	0	0	1	0	2	3	2817.0	18
310	585	668	233	312	103	64	9	13	0	0	0	0	0	0	0	3	1	2	7	3168.0	18
315	482	659	277	324	92	132	14	14	0	0	0	0	0	0	1	1	1	1	2	3493.0	18
320	561	681	227	327	78	85	17	8	1	3	1	0	0	0	1	2	1	0	7	3242.0	18
325	635	682	206	293	79	70	12	13	2	0	0	0	0	0	0	1	0	2	5	2957.0	18
330	565	686	216	316	85	89	16	6	5	3	1	0	0	0	1	2	1	0	7	3275.0	18
335	636	668	293	275	51	52	12	5	0	0	0	0	0	0	2	0	0	1	5	2785.0	18
340	641	772	218	265	51	36	5	0	0	0	0	0	0	0	1	1	1	2	7	2622.0	18
345	713	710	230	230	72	30	1	1	0	0	0	0	0	0	2	3	1	4	3	2522.0	18
350	786	720	220	213	39	12	2	1	0	0	0	0	2	1	1	0	1	2	0	2135.0	17
355	1049	701	115	112	15	1	2	0	0	0	0	3	1	1	0	0	0	0	0	1402.0	13
360	1496	399	9	95	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	706.0	4

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3. Input Impedance

After disconnecting all external input devices from the TC-2A, a direct current power supply in series with a multimeter was used to measure the resistance of each input channel. Table C-20 shows the results.

TABLE C-20. Synchro Input Impedance.

Input channel	Volts	Computer Off		Computer On	
		Current[a]	Resistance[b]	Current[a]	Resistance[b]
Radar Alt. Ch 1	25	160	56.25	190	131.5
TAS Ch. 2	4	2.25	1.8	<.1	>40
Barometric Alt.	4	2.7	1.45	<.1	>40
Mach No.	4	2.6	1.54	<.1	>40
Angle Of Attack	4	2.6	1.54	<.1	>40

[a]Current is given in microamperes.

[b]Resistance is given in megohms except for Radar Altimeter which is in kilohms.

Wheel Drivers

The TC-2 normally drives the Horizontal Situation Indicator (HSI) and the Projected Map Display Set (PMDS) in the aircraft. In the WepSIL a second HSI was added and tests made of current limiting, drive capabilities, and error.

1. Current Limiting

A standard probe (part number P6019) for a Tektronics oscilloscope was used to observe the current. The wheel drivers maintained 0.4 ampere per leg, peak-to-peak without foldback.

At any load in excess of 0.41 ampere, foldback will occur after 325 milliseconds, but the time is independent of the amount of the overload. The maximum current available after foldback is 0.4 ampere, while the maximum output before foldback is 3 amperes peak-to-peak into a short circuit load.

2. Drive Capabilities

Connector cables were made up to allow the second HSI to be quickly connected to the standard configuration of the WepSIL. Several different HSIs and PMDSs from aircraft were used during the test, to average out bias that might exist in a particular instrument. The object of the test was to determine the simultaneous response of the 3-digit readings on each of the instruments to changes in settings on the TC-2A. Each of the wheels of the instruments has ten evenly spaced digits on its circumference as does the fly-to-destination thumbwheel of the TC-2A.

Starting from present position at N 00°00'00" and W 00°00'00", nine destination coordinates in the north direction were chosen as shown below so that the wheels of the instruments would each change by five digits (180° rotation of each wheel) as the destination settings were varied through five pairs of settings.

Pair	TC-2A Thumbwheel Setting	North Coordinate Deg	Min	Sec	Instrument Wheel Response Required
1	0	00	00	00	000
	1	09	14	30	555
2	2	03	42	00	222
	3	12	55	50	777
3	4	05	33	00	333
	5	14	46	40	888
4	6	01	51	00	111
	7	11	05	30	666
5	8	07	23	30	444
	9	16	37	10	999

At room temperature in the laboratory the TC-2A drove the wheels satisfactorily with some minor sluggishness when the wheels were required to change by 180° (5 digits).

Serial Number JBB003 was used to drive all three instruments after both of the HSI's (Serial Numbers CQW205 and CXX213) had

been precooled to 20°F. On this test, one or more of the wheels (usually the hundreds and units) hung up occasionally where they were required to make a 180° change. For instance, when the destination thumbwheel was changed from 6 to 7, instead of changing from 111 to 666, the instrument's wheels read 262 about one third of the time.

The test was repeated with a TC-2 and a similar problem was noted.

3. Error

Observations were made during the drive test to determine whether the map displays were reasonably well centered and did not cause ambiguous readings.

No ambiguous readings were observed and the display of the terrain remained well centered.

Analog Reference

Tests of the analog reference voltage (±4 Vdc) were made to determine error, jitter and noise while the software was running and to determine the effect of overload on drive capability.

1. Error, Jitter, and Noise

While the software was running, the reference voltage was monitored both by an oscilloscope and a digital voltmeter.

The voltages measured were: 3.959 (3.960) Vdc. Both computers also showed a periodic burst of exponentially decreasing 1 V peak-to-peak ac signal superimposed on the 4 volts dc signal. This ac signal was a 200 kHz sine wave that lasted from 25-50 μsec at a time. This signal never seemed to come at a time that affected the analog input conversion. For neither computer was there a measurable effect when the analog potentiometers were varied.

2. Drive

The drive capability was measured by connecting the reference voltage lines to an adjustable load and decreasing the resistance until a ten percent decrease in voltage was observed.

With the potentiometers disconnected and a load of 68 ohms, the voltage was 3.562 (3.564) volts and the current approximately 52 milliamperes.

DIGITAL SIGNALS

Input (Clock, Data, Address)

The following tests were conducted to determine the capability of the TC-2A to handle serial words on both the 50kHz and 1MHz channels: common mode offset error, ability to read all bits, ability to start and stop channels 5 and 6, differential voltage requirements and ability to read channels at all phase relationships.

1. Common Mode Offset Error

The general purpose serial word generator was connected to a serial-in channel as shown in Figure C-1. The accumulator was monitored by the SDTS at a location in the program where the serial word is normally read. The variable voltage supply was adjusted until read errors were noticed or the voltage reached 15 volts, whichever occurred first.

No errors were recorded at 15 volts or lower.

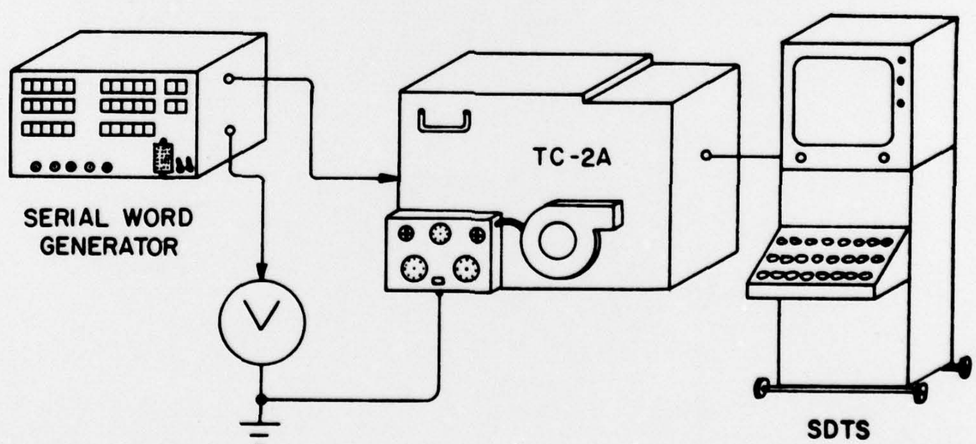

FIGURE C-1. Setup for Common Mode Offset Error.

2. Ability to Read All Bits

In order to test the capability of the TC-2A to read all bits, a special program, called SERWRD, was written for the PDP 11/45 so that it can check the serial word and direct memory access channels of the interface between the serial word generator and the TC-2A. At the same time, the OFP of the TC-2A was modified to return to the PDP 11/45 what it reads on the Doppler, FLR, HARM and SINS channels as well as Channel 5.

a. Program SERWRD can detect and report three separate types of errors, known as FIL, ER, and +ER. A description of each type follows:

FIL This type error occurs when no data are written into an expected address. If no new data are written, the filler placed in that address by the PDP 11/45 is left unaltered. This is a positive indication of an address error.

ER This type of error is a minus error. If the data received are less than the data sent, for two cycles in a row the ER message is written out. When the ER is first detected, no error is re ported. The data are sent again to make sure a true error has occurred. If the error is detected during the next cycle, an error message is written. This is a positive indication that the TC2A has not received the new data sent and/or an address has not been received correctly.

+ER This type error occurs when the data received are greater than the data sent. When a plus error is detected, it is a positive indication of a data transmission error or an addressing error.

The manner in which these data and address errors are found is presented in the following manner:

Step 1. The initial data and address were outputted after the first 40ms cycle is detected by the PDP 11/45.

Step 2. For each 40ms cycle that follows, the PDP 11/45 fills its receiving buffer with the base value outputted to the TC2A plus 1777 octal.

Step 3. The PDP 11/45 waits 4 ms before checking for data and address errors. This wait allows the latest TC2A data to be received.

Step 4. If the present cycle occurs just after an address update, the data are checked at the previous address. Otherwise, the data are checked at the present address.

Step 5. Data received are checked against data sent at the address expected. If the data are not there, or are in error, an error message is printed out.

Step 6. After the data are checked, the base output data are incremented by one and outputted to the TC-2A. The data are sent out in the following way for all channels except Doppler.

(a) First word - base data

(b) Second word - base data + 3

(c) Third word - base data + 8

Step 7. Doppler output appears as:

(a) First word - base address for channel 5

(b) Second word - base data

(c) Third word - base data + 3

Step 8. Every 100 octal cycles, the addresses for the DMA serial channels are updated. The addresses are first checked to see if their limits have been reached. The base address range for the DMA channel is A to AF hexadecimal. If the limits have been reached, they are reset to the bottom of their address range. Otherwise their addresses are incremented by one.

b. A loopback scheme was used to modify the OFP of the TC-2A so that it takes input words and loops them back as output words. One input word is used to notify the TC-2A where the DMA words will be stored. The following table shows this loopback scheme.

Loopback Scheme

Input from PDP 11/45	Read by TC-2A on channel	Output by TC-2A on channel
1. Address of 1st word of Ch. 5 2. Data 3. Data +3	Doppler	HUD
1. Data	FLR	FLR
2. Data +3	HARM	Flt Recorder 1,2,3
3. Data +8	SINS	Flt Recorder 4,5,6
	Ch. 5	Ch. 5

The TC-2A also tallies any errors such as parity or missing validity. The error count is displayed in the NAV panel window by setting the NAV panel thumbwheel to SINS X-Y.

c. Results by Serial Number JBB003, after over sixteen hours of processing data and addresses by SERWRD, showed only one error in data transmission or addressing. This error was not repeatable and was considered to not be significant as it could well have resulted from a voltage fluctuation or some other such cause in the facility hardware. Table C-21 reproduces the computer printout which revealed the single error of the plus type.

TABLE-21. Printout of SERWRD Error.

File: T0504.001 TC-2A JBB003 Program: SERWRD V14-01
May 2, 1977 Time: 1515 No Phase Shift

Total cycle count = 5,461,131 Total count = 5,461,131
Total time = 16:18:10

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Time past	Cycle	Channel	Word sent	Received	address	ER type
11:53:40	052273	010	006 052303	176372	000015	+ ER

3. Ability to Start and Stop Channels 5 and 6

The input-output program for the TC-2A was modified so that the TC-2A could halt its output. The PDP 11/45 determined whether the output of the TC-2A has stopped.

Both channels 5 and 6 were able to start and stop under program control.

4. Differential Voltage Requirements

This was a test to determine the minimum differential voltage on the serial word input channel before errors develop. The test setup is depicted in Figure C-2 in the form of a block diagram. The differential voltages going into the TC-2A are monitored by an oscilloscope as the voltages are adjusted by potentiometer R1. The data read are monitored by the SDTS. The voltage level when the first error is observed is the value noted.

The level at which errors appeared was 0.7 volts line-to-line.

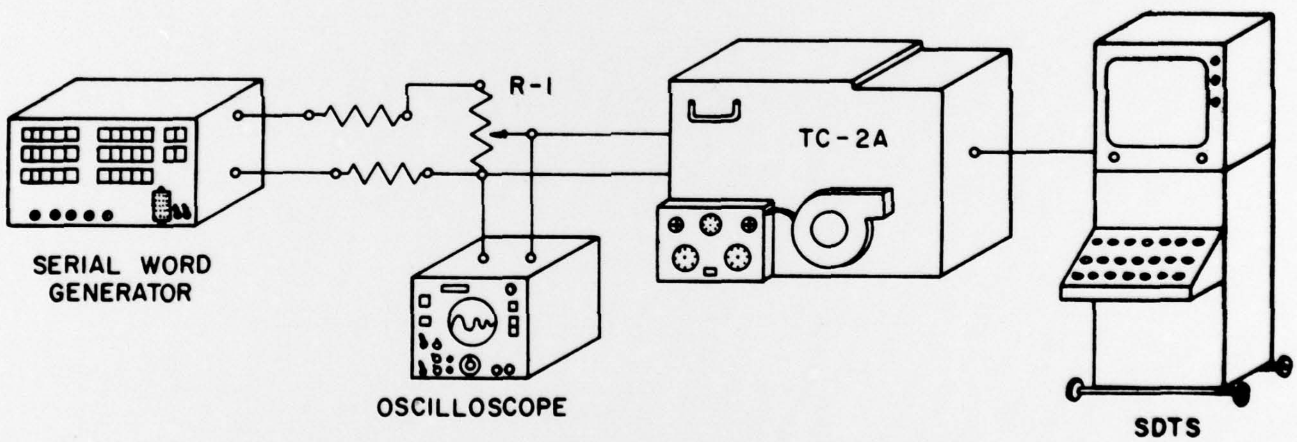

FIGURE C-2. Differential Voltage Test Setup.

5. Ability to Read Channels at All Phase Relationships

In the aircraft there is no set interval between the start of the words on the various channel. In order to determine whether errors might be generated by a particular combination of phases, such as all words arriving at the same time, each word delayed by one clock pulse or the like, a special tool was designed and

built in the form of a computer-controlled phase shifter to be used with the SERWRD program, and modified to test the phase relationships between channel. The procedure is the same as that for checking the TC-2A's capability to read all bits, except for two added conditions.

a. The initial phase relationship(s) is setup at Step 1.

b. At the time the addresses are updated (Step 6), the phase relationships between channels are also updated. The phases are rotated so that all major phase combinations are tried every 54 seconds, including all channels received simultaneously by the TC-2A.

In a run of twelve hours duration, no errors were detected.

Serial Word Output

The following tests of the serial word output functions of the TC-2A were: amplitude and phase shift; readability and word sensitivity; works in burst mode; ability to send all bit combinations; and drive capabilities.

1. Amplitude and Phase Shift

The signal amplitude on each of the four differential pair output channels was measured under normal operating conditions. The amount of phase shift, or timing lag, between the clock and the data signal was determined.

Measurements of amplitude and phase shift are given in Table C-22.

TABLE C-22. Output Amplitude and Phase Shift.

Output Channel	Amplitude (volts)	Phse Shift (nanoseconds)
Data	4.8 (4.8)	200 (208) After 90%
Address	4.8 (4.8)	200 (65) clock level
Data Ready	4.8 (4.8)	225 (48) shift
Clock	4.8 (4.6)	(All others relative to clock)

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2. Readability and Word Sensitivity

These two areas were tested for all bit combinations of the basic 16-bit data word, using the computer-based serial word tests described in the discussion of ability to read all bits for serial word input signals.

No errors were discovered under any combination of data bits.

3. Channels 5 and 6 Work in Burst Mode

The serial word program of the TC-2A was modified so that the validity set of the input and output words on both channels 5 and 6 when bit 0 (zero) of discrete input word 5 was set. The output should stop within one cycle (40 ms) after the discrete is set.

No errors occurred.

4. Ability to Send All Bit Combinations

All possible data-bit combinations were used during the loop type test described in the section on ability to read all bits.

No errors were discovered.

5. Drive Capabilities

All serial word output lines were disconnected from the TC-2A and replaced by variable resistive loads. The resistance was then decreased until the output voltage had been reduced by ten percent. The conditions for both TC-2A computers appear in Table C-23.

TABLE C-23. Drive Capabilities.

Channel	Resistance (kohm)	Output (volts)	Current (mA)
HUD Data	1.2 (1.5)	4.5 (4.5)	3.75 (3.00)
Flt Recorder	1.3 (1.5)	4.5 (4.5)	2.46 (3.00)
FLR Output	1.5 (1.5)	4.5 (4.5)	3.00 (3.00)
Channel 6A	1.6 (1.5)	3.6 (4.5)	2.25 (3.00)

Clocks

The clocks of the TC-2A were checked for proper frequency and channel 5 for its range of frequencies.

1. Frequency

Frequency-selected channel clocks were measured with standard frequency meters to ensure they were within specification. The measurements made for channels 2, 6, and 1 MHz are given in Table C-24.

TABLE C-24. Frequency Measurements.

Channel	Frequency (kHz)
2	50.000 (49.9996)
6	50.000 (49.9996)
1 MHz	999.9861 (999.998)

2. Frequency Range

The clock of channel 5 was driven by a variable frequency source.

Errors were detected at about 200 kHz. But, since this frequency exceeded the value in the specification, no attempt was made to determine whether the errors were generated in the TC-2A or in the WepSIL receiver.

Discrete Inputs

The discrete inputs of the TC-2A were checked for input threshold voltage and impedance. A representative sample of discrete input circuits was tested by applying varying voltages, or resistances to ground, as appropriate to determine the threshold voltage or impedance at which the TC-2A detects a logic change. Table C-25 shows the measurements made.

TABLE C-25. Tests of Discrete Input Circuits.

Discrete Input	Varying Condition	Logic Change Occurs	
Weapon type 80	0-5 volts	2.433/2.665 V	(2.351/2.506 V)
Station 1 ready		2.448/2.587 V	(2.419/2.475 V)
Normal mode	Short/Open	1.490 kΩ	(1.42 kΩ)
NAV/Bomb	Short/Open	1.444 kΩ	(1.34 kΩ)
Target designator	0-28 volts	6.283/6.420 V	(6.412/6.484 V)

Central Processing Unit

The CPU was checked to confirm the amount of time left after a full cycle and to exercise the new instructions included in the design of the TC-2A.

1. OFP Timing

The OFP was modified to measure the amount of time left at the end of each navigation cycle, a NAV cycle starts every 200 millisec, and to display that information on command. The program was run with the TC-2, the TC-2A preproduction, and the TC-2A units under several different modes to observe the magnitude of difference in speed. Table C-26 charts these data. The average ratio between TC-2 NAV cycle time and TC-2A NAV cycle time was between 2.14 and 2.28.

TABLE C-26. Time Remaining in Each Navigation Cycle.

Moding	Attack Mode	TC-2 (ms)		TC-2A (ms)	
		Minimum	Average	Minimum	Average
MAG SLAVE	TERR FOLLOWING	64.54	73.45	140.72	142.57
MAG SLAVE	RADAR ATTK	39.20	45.51	129.20	132.32
MAG SLAVE	NORM/OFFSET	36.12	44.72	129.12	132.01
MAG SLAVE	NORM ATTK	37.92	43.71	127.80	131.15
MAG SLAVE	NAV. CCIP	22.48	46.15	126.30	128.09
NORM	CLEAR	64.40	68.70	140.22	141.73
NORM	NORM/OFFSET	41.10	47.28	128.16	131.80
GND ALIGN	CLEAR	82.40	89.88	147.38	149.82

2. New Instructions

The new instructions included in the TC-2A repertoire were incorporated in test programs and in the OFP that was used in the flight test phase.

All operations were within specification and no errors were discovered.

FLIGHT TESTS

The TC-2As were tested during normal test flights of A-7E aircraft. There were three objectives in carrying out these flights:

1. To have the computer subjected to the environment and interfaces of the A-7 aircraft.

2. To have experienced A-7 pilots use the equipment in order to detect any noticeable differences in operation from that of the TC-2.

3. To demonstrate as many flight hours as possible without hardware failure.

The total time of testing logged for Serial Number JBB002 (JBB003) was 788 (571) hours. Of these, 604 (477) hours were in the WepSIL and the remaining 184 (94) hours with the computer installed in an A-7E aircraft. A portion of this time was in actual flight.

No component failures were detected and no pilot complaints that could be attributed to the TC-2A were logged.

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GLOSSARY

A REG	Accumulator Register
B REG	Buffer Register
CPU	Central processing unit
CRT	Cathode ray tube
DDC	Data Device Corporation
DMA	Direct memory access
DMCM	Double modular core memory
DME	Distance measurement equipment
D/S	Digital-to-synchro
FLIR	Forward looking infrared
FLR	Forward looking radar
HSI	Horizontal situation indicator
HUD	Head-up display
IBM	International Business Machines Corporation
IC	Instruction counter
IMS	Inertial measurement set
I/O	Input-output
LED	Light emitting diode
MUX	Multiplexer
NWC	Naval Weapons Center
NWDC	Navigation and weapons delivery computer
NWDS	Navigation and weapons delivery system
OFP	Operational flight program
PMDS	Projected map display set
Q bus	Quotient register bus
Q REG	Quotient register bus
SAR	Storage address register
SBR	Storage buffer register
S/D	Synchro-to-digital
SDTS	Software development test system
TC-2	Navigation and weapons delivery computer in fleet A-7E aircraft
TC-2/A	Upgraded TC-2
WepSIL	Weapons System Integration Laboratory

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